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FINAL SAMPLING AND ANALYSIS PLAN FOR THE SITE CHARACTERIZATION OF THE 903 DRUM STORAGE AREA (IHSS 112), 903 LIP AREA (IHSS 155), AND AMERICIUM ZONE

RF/RMRS-97-084

Environmental Restoration
Rocky Flats Environmental Technology Site

August 1998
Revision 1

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Document Control No: RF/RMRS-97-084

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August 24, 1998
Revision 1

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EXECUTIVE SUMMARY

Radiological contamination of surface soils exceeding Rocky Flats Cleanup Agreement (RFCA) Tier I soil action levels at the 903 Drum Storage Area (903 Pad), 903 Lip Area (Lip Area), and the Americium Zone are known from previous investigations. Contamination was a result of releases associated with the historical use of the 903 Pad for outdoor storage of drums containing volatile organic compounds (VOCs) contaminated with plutonium and uranium from 1958 until 1967. The 903 Pad and Lip Area were sources of radiological contamination impacting surface soil. VOCs have impacted groundwater as a result of leaking drums.

The purpose of this sampling and analysis plan (SAP) is to further refine the volume estimates of radiologically-contaminated surface soils, radiologically-contaminated subsurface soils, and VOC-contaminated soils (i.e., above RFCA action levels) for selection of appropriate remedial designs, as well as the asphalt covering the 903 Pad.

Characterization of the areal extent of radiologically-contaminated surface soils will utilize *in situ* gamma-ray spectroscopy methodology with high purity germanium (HPGe) units mounted at a detector height adequate to define the specific field of view when combined with the appropriate collimator /shield. Given this orientation, approximately 90 percent (%) of the gamma-rays measured by the detector originate from a circle on the ground whose diameter is approximately 10 to 12 meters (32 to 39 feet). This is often referred to as the detector's field of view (FOV). HPGe measurement results will be correlated to soil sample results collected at the measurement location (i.e., FOV).

Investigation decision levels for the HPGe survey are: 1) contamination defined by radionuclide concentrations in soils equal to or above RFCA Tier I soil action levels using the sum of ratios equation; and 2) cessation of surveying based on two contiguous HPGe measurement results less than 10 pCi/g americium-241 (^{241}Am) within the investigation boundary limit.

The vertical extent of radiological contamination at the 903 Pad, Lip Area, and the Americium Zone will be determined based on previously collected data and if needed by using a statistically based grid to locate shallow soil borings. Subsurface soil samples collected at these locations will be analyzed at a laboratory for isotopic determination. Subsurface soil sample results above RFCA Tier I soil action levels will define the vertical and lateral extent of radiologically-

contaminated soil at the 903 Pad and Lip Area for input into the remediation estimate. Boundaries of radiologically-contaminated subsurface soil at the 903 Lip Area will be refined by "step-out" borings located at half the grid distance between borings with results below Tier I soil action levels and a boring with results above RFCA Tier I soil action levels.

Characterization of VOC-contaminated soil will utilize a judgmental sampling strategy with soil borings radially placed upgradient of two VOC-contaminated groundwater wells at the 903 Pad and historical drum storage areas. Groundwater data for these wells indicates carbon tetrachloride and tetrachloroethene present at concentrations greater than ten percent of their respective aqueous solubilities. A soil boring will also be completed at the soil gas anomaly in the Lip Area, southeast of the 903 Pad. Subsurface soil samples will be collected for VOC and radiochemical analyses. Additional (step-out) borings will be completed on the basis of analytical results greater than 10 percent of the Tier I subsurface soil action level for VOCs.

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LIST OF ACRONYMS

ALF	Action Level Framework
ASD	Analytical Services Division
CDH	Colorado Department of Health
cm	centimeters
cpm	counts per minute
DOE	US Department of Energy
DNAPL	Dense Non-Aqueous Phase Liquid
DQO	Data Quality Objective
EA	Exposure Area
EPA	Environmental Protection Agency
ERM	Environmental Restoration Management
FIDLER	Field Instrument for the Detection of Low Energy Radiation
FO	Field Operations
FOV	Field Of View
ft^2	square feet
GT	Geotechnical
GPS	Global Positioning System
HPGe	High Purity Geranium
IDM	Investigative Derived Material
in	inches
IHSS	Individual Hazardous Substance Site
K-H	Kaiser-Hill
LDR	Land Disposal Restriction
m	meters
mg/kg	milligrams per kilogram
mg/L	milligrams per Liter
NAPL	Non-Aqueous Phase Liquid
OU	Operable Unit
OVM	Organic Vapor Meter
%	percent
pCi/g	Picocuries Per Gram
PARCC	Precision, Accuracy, Representativeness, Completeness, and Comparability
PID	Photoionization Detector
QAPD	Quality Assurance Project Description
QA	Quality Assurance
QC	Quality Control
RFI/RI	Resource Conservation and Recovery Act Facilities Investigation/ Remedial Investigation
RFCA	Rocky Flats Cleanup Agreement
RFEDS	Rocky Flats Environmental Database System
RFETS	Rocky Flats Environmental Technology Site
RMRS	Rocky Mountain Remediation Services, L.L.C.
ROD	Record of Decision
ROI	Radiological Operations Instructions

LIST OF ACRONYMS (Cont.)

RPD	Relative Percent Difference
SAP	Sampling and Analysis Plan
SOP	Standard Operating Procedure
SSOC	Safe Sites of Colorado, L.L.C.
ug/L	Micrograms per Liter
ug/Kg	Micrograms per Kilogram
VOC	Volatile Organic Compound

STANDARD OPERATING PROCEDURES

NUMBER	PROCEDURE TITLE
5-21000-OPS-FO.1	Air Monitoring and Particulate Control
5-21000-OPS-FO.03	Field Decontamination Procedures
4-S02-ENV-OPS-FO.04	Decontamination of Equipment at Decontamination Facilities
5-21000-OPS-FO.06	Handling of Personal Protective Equipment
5-21000-OPS-FO.07	Handling of Decontamination Water and Wash Water
4-K56-ENV-OPS-FO.08	Monitoring and Containerizing Drilling Fluids and Cuttings
4-K56-ENV-OPS-FO.09	Handling of Residual Samples
4-K55-ENV-OPS-FO.10	Receiving, Marking, and Labeling Environmental Materials Containers
5-21000-OPS-FO.11	Field Communications
5-21000-OPS-FO.12	Decontamination Facility Operations
RMRS/OPS-PRO.069	Containing, Preserving, Handling and Shipping of Soil and Water Samples
5-21000-OPS-FO.15	Photoionization Detectors and Flame Ionization Detectors
4-F99-ENV-OPS-FO.23	Management of Soil and Sediment Investigative Derived Materials
4-H46-ENV-OPS-FO.29	Disposition of Soil and Sediment Investigation Derived Materials
5-21000-OPS-GT.01	Logging Alluvial and Bedrock Material
5-21000-OPS-GT.02	Drilling and Sampling Using Hollow-Stem Auger Techniques
5-21000-OPS-GT.05	Plugging and Abandonment of Boreholes
4-E42-ER-OPS-GT.08	Surface Soil Sampling
5-21000-OPS-GT.10	Borehole Clearing
1-F20-ER-EMR-EM.001	Approval Process for Construction/Excavation Activities
4-S64-ER-GT.39	Push Subsurface Soil Sample
4-61100-REP-14.01	Operation of Gamma Ray Spectroscopy System
4-R29-REP-14.02	Routine Characterization of HPGe Detectors
4-H58-ROI-06.6	Use of Bicron FIDLER
2-S47-ER-ADM-05.14	Use of Field Logbooks and Forms
RF/RMRS-98-200	Evaluation of Data for Usability in Final Reports

STANDARD OPERATING PROCEDURES - (Cont.)

NUMBER	PROCEDURE TITLE
1-50000-ADM-12.01	Control of Measuring and Test Equipment
3-21000-ADM-17.01	Quality Assurance Records Requirements
1-C88-WP1027-NONRAD	Non-Radioactive Waste Packaging
1-M12-WO4034	Radioactive Waste Packaging Requirements
4-C77-WO-1101	Solid Radioactive Waste Packaging
1-C80-WO-1102-WRT	Waste/Residue Traveler Instructions
PADC-96-00003	WSRIC for OU Operations, Version 6.0, Section No. 1
1-PRO-079-WGI-001	Waste Characterization, Generation, and Packaging

1.0 INTRODUCTION

The purpose of this Sampling and Analysis Plan (SAP) is to estimate the volume of soils exceeding the Rocky Flats Environmental Technology Site (RFETS) Cleanup Agreement (RFCA) Action Level Framework (ALF) Tier I Soil Action Levels or other action levels identified as being protective of surface water for radionuclides and volatile organic compounds (VOCs) at the 903 Drum Storage Area (903 Pad, Individual Hazardous Substance Site [IHSS] 112), the 903 Lip Area (Lip Area, IHSS 155), and the Americium Zone (Figure 1.1). The 903 Pad, Lip Area, and Americium Zone are located in the Buffer Zone Operable Unit (OU). The scope of this SAP also includes the surface soils of OU No.1, 881 Hillside, which have been administratively incorporated into the Buffer Zone OU (DOE, 1995b). The Buffer Zone OU has been designated for restricted open space land use.

In 1996 the Actinide Migration Expert Panel was formed to review existing data on actinide migration at RFETS and make recommendations for future work. Panel recommendations included developing a conceptual model for actinide transport, based on a thorough understanding of chemical and physical processes; investigating the long-term impacts of actinide geochemical mobility on remedial requirements; and evaluating the protectiveness of the RFCA soil action levels to surface water quality. This SAP has incorporated data interpretations from the Actinide Migration Expert Panel presented in the *Summary of Existing Data on Actinide Migration at the Rocky Flats Environmental Technology Site* (DOE, 1997a). Based on modeling currently being performed by the Actinide Migration Expert Panel, revisions to this SAP may be necessary. **However, measurement techniques purported in this SAP provide adequate sensitivity to identify soils exceeding much lower soil action levels than those currently stipulated by RFCA, should the Actinide Migration Expert Panel conclude that soil action levels be lowered to protect surface waters.**

The Americium Zone is defined as the general area located outside the 903 Pad and Lip Area within the RFETS boundaries that have been impacted by past waste disposal and/or cleanup activities associated with the 903 Pad and 903 Lip Area. The Americium Zone exhibits americium-241(^{241}Am) activities above background levels as defined by the *Geochemical Characterization of Background Surface Soils: Background Soils Characterization Program*

Figure 1.1

(DOE, 1995d). Based on that program, the mean background activity for ^{241}Am for Front Range soils is 0.0107 picocuries per gram (pCi/g).

Implementation of this SAP will provide a more accurate estimate of the volume of soil exceeding Tier I soil action levels for a remedial alternative analysis. Tier I soil action levels are numeric levels, that, when exceeded, trigger an evaluation, remedial action or management action (DOE, 1996). Tier I soil action levels for radionuclides are based on the sum of ratios equation (see Section 2.5.1). Existing data suggests that an interim remedial action will be warranted. The estimated volume of contaminated soil calculated from data generated by this investigation will be used as input data for a remedial alternative analysis in a future interim measure/interim remedial action (IM/IRA) or Proposed Action Memorandum (PAM).

Investigation decision levels for the HPGe survey are: 1) contamination defined by radionuclide concentrations in soils equal to or above RFCA Tier I soil action levels; and 2) cessation of surveying based on two contiguous HPGe measurement results less than 10 pCi/g americium-241 (^{241}Am) within the investigation boundary limit.

1.1 Background

Releases at the 903 Drum Storage Site (IHSS 112) are considered the primary source of radiological contamination in the surficial soil in this part of RFETS. Drums that contained radiologically-contaminated oils and VOCs were stored at this location from the summer of 1958 to January 1967. Approximately three fourths of the drums contained plutonium-contaminated liquids while most of the remaining drums contained uranium-contaminated liquids. Of the drums containing plutonium, the liquid was primarily lathe coolant and carbon tetrachloride in varying proportions. Also stored in the drums were hydraulic oils, vacuum pump oils, trichloroethene, tetrachloroethene (perchloroethylene), silicone oils, and acetone still bottoms (DOE, 1995a).

Leaking drums were noted in 1964 during routine handling operations. The contents of the leaking drums were transferred to new drums, and the area was fenced to restrict access. When cleanup operations began in 1967, a total of 5,237 drums were at the drum storage site. Approximately 420 drums leaked to some degree. Of these, an estimated 50 drums leaked their

entire contents. The total amount of material released was estimated at 5,000 gallons of contaminated liquid containing approximately 86 grams of plutonium (DOE, 1995a).

From 1968 through 1970, some of the radiologically-contaminated material was removed, the surrounding area was graded, and much of the area was covered by an imported base coarse material (artificial fill) and asphalt cap. However, during drum removal and cleanup activities, wind and rain spread plutonium-contaminated soils to the east and southeast from the 903 Pad area resulting in IHSS 155 (903 Lip Area). Several limited excavations in 1976, 1978, and 1984 have removed some of the plutonium-contaminated soils from the Lip Area (DOE, 1995a, Barker, 1982, and Setlock, 1984). However, sampling and analysis results from the OU2 Phase II RFI/RI (DOE, 1995a) confirm that radiologically-contaminated soils remain.

Surface soils to the east and southeast of the Lip Area also exhibit elevated plutonium-239/240 ($^{239/240}$Pu) and ^{241}Am activities. This contamination is primarily attributed to wind dispersion from the 903 Pad with potential contributions from historical fires and stack effluent. Areas exhibiting elevated $^{239/240}$Pu and ^{241}Am activities east and southeast of the Lip Area are known as the Americium Zone.

In 1989, the Federal Bureau of Investigations sent a "Tiger Team" of investigators to RFETS. The Tiger Team reported observing at least two areas where erosion was occurring or had recently occurred and that the eroded material contained elevated readings on hand held radiation detectors. The DOE Remote Sensing Laboratory in Las Vegas, Nevada, was contracted to perform fly-over gamma-ray spectrometry surveys of the site, truck and tripod-mounted gamma-ray spectrometry measurements, and traditional soil sampling in an attempt to assess the radiological conditions.

It was subsequently recognized that a gamma-ray spectrometry analytical capability was needed at RFETS. A team of experts was formed in 1991 by EG&G Rocky Flats, the Site management and operating contractor at that time, for the purpose of assembling and establishing a high purity germanium (HPGe) gamma spectrometry program onsite. This team assembled a mobile system using an array of six, 75% relative efficient, N-type HPGe detectors. The array was attached to a telescoping mast which could position the detector package from 10 centimeters (cm) to over 6.5 meters (m) above the ground. This truck-mounted array was utilized to perform systematic *in* *situ* measurements at selected areas.

1.1.1 Overview of *In Situ* Gamma-ray Spectroscopy

Simply stated, the measurement takes place with the sensor positioned over the area of interest and a gamma-ray energy spectrum is collected over a period of time. If there is material between the area to be characterized and the detector such as water/snow, gravel, pavement, concrete, or even clean soil then the measurement becomes more complex. Any material between the sensor and the area of interest will reduce the amount of unscattered flux effectively shielding a potential source term.

In the past, simple counting systems moved from the laboratory to the field and today there are countless models of 'health physics' instrumentation. In 1972 Harold Beck with his colleagues, J. DeCampo and C. Gogolak at the United States Atomic Energy Commission, Health and Safety Laboratory now called the United States Department of Energy, Environmental Measurements Laboratory, published a paper entitled *In situ Ge(Li) and NaI(Tl) Gamma-Ray Spectrometry,* HASL 258. This document has become the 'bible' to the *in situ* gamma-ray spectroscopist. HASL 258 shows that the *in situ* measurement integrates the activity over a large volume and the results can be presented as activity per unit mass averaged over the measured volume. The spatial variability of the activity is smoothed and a more representative value for the activity in a given plot of land could be obtained. This methodology does not pre-empt the requirement for soil samples but rather enables the investigator to develop a more meaningful sample strategy.

In situ gamma-ray spectrometry provides several benefits over other analytical methods. Gamma-ray spectrometry measurements allow a rapid return of data (i.e., within 24 hours), while producing quantitative estimates of the activities of radioactive isotopes present. A larger volume of sample may be analyzed, thereby allowing a more representative determination of the radioactive isotopes present. Gamma-ray spectrometry analysis does not require sample dissolution, thus eliminating errors caused by incomplete dissolution and matrix interference. *The Compendium of In Situ Radiological Methods and Applications at Rocky Flats Plants* (EG&G, 1993) provides a detailed discussion on the physics of *in situ* measurement of radionuclides in the environment.

The technique is currently in use at the DOE's Fernald Site in support of the D&D activities. *In* *situ* gamma-ray spectrometry has been successfully used at DOE's Nevada Test Site to provide source term information for dose calculations. It has been used in support of the cleanup of the Marshall Islands as well as the Johnston Atol. The method also supported the cleanup of the former sampling plant located at Middlesex, New Jersey. In short, the method has supported and is supporting environmental assessment of radionuclides for almost three decades including Rocky Flats.

Previous investigations at OUs 1, 2, 9, and 10 utilized *in situ* gamma-ray spectrometry measurements for human health and environmental risk assessments. Examples of HPGe investigations include the *881 Hillside Hot Spot Removal Project in OU1* (DOE, 1995c). This project was performed successfully with regulatory approval of the technique.

HPGe gamma-ray spectrometry methodology will be used during this investigation for further refining the areal extent of radiologically-contaminated soil for planning remedial alternatives for the Americium Zone and the Lip Area. HPGe surveys in a portion of the Lip Area may be omitted in the event the subsurface soil sampling program identifies natural soils (beneath the artificial fill) exceeding Tier I soil action levels in this area.

1.1.2 Project Study Area

The project study area for this investigation was selected to include surface and subsurface soils in the primary source area (903 Pad), the secondary source area (Lip Area) and areas impacted downwind of the source (Americium Zone). The study area represents the area in which data were evaluated to determine locations where an exceedance to RFCA Tier I soil action levels may be present. This represents an area bounded by Indiana Street to the east, Pond C-2 to the south, Pond B-5 to the north, and Building 886 to the west (excluding areas inside the protected area [PA]). Figure 1.1 shows the extent of the study area.

The study area includes locations sampled under three surface soil sampling programs conducted in support of the OU2 RFI/RI (DOE, 1995a) and locations sampled under one surface soil sampling program performed under the OU1 RFI/RI (DOE, 1994a). Subsurface soil analytical results were also obtained from samples collected from boreholes completed for numerous projects including the OU1 and OU2 RFI/RIs. Subsurface soil samples were also collected beneath the 903 Pad in support of a soil decontamination feasibility study and from 26 soil profile excavations completed during the OU2 RFI/RI. The study area also includes areas identified by data collected from two previous HPGe investigations.

1.1.3 Project Investigation Area

Existing data in the study area were compiled and evaluated with respect to the Tier I soil action levels to determine areas suspected to exceed RFCA Tier I soil action levels. The Investigation Area represents the area where additional characterization is required to refine the volume estimate of contaminated soils (Figure 1.2). The area requiring additional characterization is hereafter identified as the Investigation Area. The Investigation Area represents that portion of the study area which is known, or which a potential exists, for surface and/or subsurface soils to exceed Tier I soil action levels. These areas include:

- Surface soils exceeding 10 pCi/g ^{241}Am as identified from the 1990 and 1994 HPGe Surveys;
- Areas where artificial fill has been placed over natural soils including the 903 Pad, Lip Area, and areas remediated in 1976, 1978, and 1984;
- Five 2.5-acre plots identified as exceeding Tier I soil action levels based on OU2 RFI/RI surface soil sample results; and
- The 903 Pad and Lip Area where a subsurface VOC source is suspected as the source of a groundwater contaminant plume.

1.2 Existing Data Summary

Numerous investigations to assess the extent of contamination at the 903 Pad, Lip Area, and Americium Zone have been conducted. These investigations are briefly described below.

1.2.1 Surface Soils

HPGe Surveys - In situ gamma-ray spectrometry surveys (i.e., HPGe surveys) were conducted in 1990 (EG&G, 1991) and 1994 (RMRS, 1996) using the truck-mounted array to generate data on the activity of ^{241}Am in surface soils in the Americium Zone. Data was collected from a grid consisting of a 45.7 m (150 ft) diameter circle for the truck mounted array's FOV of 1,642 m^2 (17,671ft^2 or 0.4 acre). HPGe surveys were not conducted over the 903 Pad and the eastern portion of the 903 Lip Area. Surface soil samples were not collected to correlate HPGe survey results to ^{241}Am activities. The HPGe measurements identified from the previous HPGe surveys containing ^{241}Am above 10 pCi/g are included within the boundaries of the Investigation Area (Figures 1.2, and 1.3). Surface soil plots PT035, PT045, PT047, PT048, PT054, PT055, PT062

Figure 1.2

Figure 1.3

were included within the Investigation Area based on this rationale. HPGe measurements collected within the study area and used to delineate the Investigation Area are provided in Figure 1.3.

Surface Soil Radiological Data - Surface soil samples were collected in support of the OU2 Phase II RFI/RI (DOE, 1995a) and the OU1 Phase III RFI/RI (DOE, 1994a). Figure 1.4 provides the locations of OU2 RFI/RI (DOE, 1995a) surface soil plots and locations where results exceeded RFCA Tier I soil action levels for radionuclides. Figure 1.5 provides the locations of OU1 RFI/RI surface soil plots. No surface soil sample results from OU1 RFI/RI surface soil plots exceeded RFCA Tier I soil action levels for radionuclides.

As detailed in the OU2 RFI/RI, surface samples were collected from 124 plots utilizing two sampling methods: Colorado Department of Health (CDH) sampling method and the Rocky Flats (RF) sampling method. Surface soil sample results were compared with RFCA Tier I surface soil action levels and the HPGe survey results. The comparison indicated that samples collected from five 2.5-acre plots exceed the Tier I soil action levels which correlated well with the HPGe results (Figures 1.3 and 1.4). These plots include two 2.5-acre plots (PT028 and PT034) sampled under the CDH sampling program and three 2.5-acre plots (PT029, PT036, and PT046) sampled under the RF sampling program (Figure 1.4).

The RF sampling methodology consists of compositing 10 grab samples collected at the corners and center of two one-meter square grids separated by a one square meter grid to a two inch depth. These sample results represents the physical averaging of activity in soils over a two square meter area. The CDH sampling methodology consists of collecting 25 grab samples over the entire 2.5- or 10-acre plot (2.5-acre plot in this case) to a depth of 0.64 cm (0.25-in). The CDH sample results represent the physical average of activity over the 2.5-acre plot. The discrepancy between method results of the CDH and RF methods is evident by the fact that no single plot was identified as exceeding action levels based on both sampling method results. This indicates that possibly only a portion of the plots identified by the RF method may exceed action levels and/or that the exceedance may be isolated from the contiguous radionuclide contaminated area which is indicative of a radiological "hot spot" (DOE Order 5400.5). Hot spot as defined for this investigation are the RFCA Tier I action levels averaged over a 100 m^2 area

Figure 1.4

Figure 1.5

for radionuclides protective of 85 millirem per year (mrem/yr) exposure to a hypothetical future resident (DOE, 1996a, per DOE Order 5400.5).

Results from these investigations were used as one source of data by the Actinide Migration Expert Panel in the generation of the surface soil ^{241}Am and $^{239/240}$Pu isoconcentration contour maps presented in the *Summary of Existing Data on Actinide Migration at the Rocky Flats Environmental Technology Site* (DOE, 1997a). These maps show elevated activities nearer the 903 Pad with decreasing activities moving eastward.

1.2.2 Subsurface Soils

Subsurface Soil Radiological Data - Three data sources were evaluated to determine the depth of radiological contamination within the Investigation Area: 1) OU2 Phase II RFI/RI borehole data (DOE, 1995a); 2) OU2 Phase II RFI/RI soil profile pits (DOE, 1995a); and 3) samples collected in support of a soil decontamination project (Rutherford, 1981).

Samples collected from soil profile pit TR08 (Figure 1.2) exceeded RFCA Tier I soil action levels to a depth of 27 centimeters (cm) (10.6 inches[in]). Soil profile pits were sampled at 3 cm (1.2 in) intervals to a total depth of 1 m (3.28 ft). Samples collected at soil profile pit TR06, located adjacent to pit TR08, were not analyzed because activities exceeded the DOT shipping requirements. It is assumed that radiochemical results from pit TR06 (Figure 1.2) would also have exceeded RFCA Tier I soil action levels, if analyzed. The depth of artificial fill in the Lip Area is approximately 2 cm (0.8 in) to 13 cm (5.1 in) (DOE, 1995a).

Soil samples collected beneath the 903 Pad in support of the soil decontamination project (Rutherford, 1981) exceeded Tier I soil action levels to a depth of 66 cm (26 in). This depth exceeds the 8 cm (3 in) thickness of the asphalt pad and the 20 cm (8 in) depth of artificial fill and indicates radiological contamination of artificial fill or natural undisturbed soils at the 903 Pad. However, none of the 903 Pad OU2 Phase II RFI/RI soil borings detected radiological contamination in excess of Tier I soil action levels. As a result, a discrepancy in the areal extent and depth of radiological contamination between these investigations exists. This area is included in the Investigation Area.

Asphalt Data - No data exists for the 903 Pad asphalt.

Subsurface Soil VOC Data - Three sources of data were evaluated to determine the nature and extent of subsurface VOC contamination at the 903 Pad: 1) OU2 Phase II RFI/RI borehole data (DOE, 1995a); 2) IM/IRA soil gas survey results (DOE, 1994b); and 3) groundwater monitoring well data. Borehole sample results were compared with RFCA Tier I soil action levels which indicated that none of the samples exceeded the Tier I action levels for VOCs. Borehole 06691 encountered carbon tetrachloride with a maximum concentration of 180 µg/Kg at a depth of 7.25 m (23.8 ft) with bedrock at 6.7 m (22 ft) (Figure 1.2). The soil gas survey indicated that the highest subsurface VOC concentrations were located immediately south of the southeast corner of the 903 Pad. Tetrachloroethene was detected at 27,000 µg/L at a depth of 1.5 m (5 ft). However, at adjacent soil gas locations and boreholes, tetrachloroethene is either not detected or detected at very low concentrations. Soil gas concentrations for the remaining portion of the 903 Pad ranged from 0 -500 µg/L with the highest concentrations around boreholes 08691 and 08891.

1.2.3 Groundwater

To target subsurface soil areas with potential VOC concentrations above RFCA Tier I soil action levels, groundwater data were also reviewed. The data were compiled from the OU2 Phase II RFI/RI (DOE, 1995a) and the Rocky Flats Environmental Database System (RFEDS) which indicated a VOC-contaminated groundwater plume originates from the 903 Pad area and extends to the east. The highest concentrations of VOCs are found in groundwater samples collected from wells 06691 and 08891 located on the asphalt portion of the 903 Pad (see Figures 1.2 and 3.4 for well locations). Concentrations of VOCs in groundwater decrease rapidly moving eastward from the 903 Pad area. This decrease in concentration may be a result of the hydraulic dispersivity reflected in the distance between the two wells and downgradient well locations.

The primary groundwater contaminant in well 06691 is carbon tetrachloride with concentrations ranging from 12,000 to 100,000 µg/L. Methylene chloride (150 to 35,000 µg/L) and chloroform (92 to 49,000 µg/L) are also observed. Groundwater sample results for well 08891 indicate the primary contaminant as tetrachloroethene at concentrations ranging from 8,800 to 20,000 µg/L, along with carbon tetrachloride (2,300 to 17,000 µg/L), cis-1,2-dichloroethene (94 to 2,900 µg/L) and trichloroethene (1,300 to 4,600 µg/L). The next highest concentration of carbon tetrachloride in groundwater is found in samples collected from well 13191, which is located west of well 06691 and off the western edge of the 903 Pad. At this location, observed carbon tetrachloride levels ranged from 122 to 4,800 µg/L.

Because of the complex nature of DNAPL transport and fate, DNAPL may often be undetected by direct methods leading to incomplete site assessments and inadequate remedial designs (EPA, 1992). A guide for estimating the potential for a DNAPL source at a site includes assessing if concentrations of DNAPL-related chemicals in groundwater are greater than 1 percent (%) of the pure phase solubility of the DNAPL compound (EPA, 1992).

Table 1.1 provides a comparison of the pure phase aqueous solubility and concentrations of DNAPL compounds detected in groundwater at or near the 903 Pad. The comparison indicates that tetrachloroethene and carbon tetrachloride have been detected in groundwater samples at 10% and 12% of their aqueous solubilities, respectively. Based on the results of this comparison and known historical site uses, there is a high potential for DNAPL and VOC contaminants above the Tier I soil action levels beneath the 903 Pad.

Radionuclide contamination in groundwater was investigated by reviewing groundwater monitoring well sample results from 1991 to 1995. Groundwater in one well, 09091 (Figure 1.2), contains ^{241}Am and $^{239/240}$Pu activity in excess of Tier I action levels for groundwater. Tier I action levels for ^{241}Am and $^{239/240}$Pu are 14.5 pCi/L and 15.1 pCi/L, respectively. Well 09091 has maximum activities of 354.6 pCi/L of ^{241}Am and 46.5 pCi/L of $^{239/240}$Pu. Uranium isotopes have not been detected in excess of their respective background activities in groundwater samples collected over this period.

1.3 Geologic Setting and Contaminant Summary

The surficial geology in the Investigation Area consists of Quaternary alluvium, colluvium and slump deposits along with artificial fill, soil and debris deposits, and disturbed soil. The surficial deposits overlie bedrock which consists of weathered claystone and minor bedrock sandstones of the Cretaceous Arapahoe and Laramie Formations. Surficial deposits consist of sandy clay and clayey gravel. Soil developed over the alluvium is rocky and sandy in contrast to the clayey soils developed over the claystone bedrock.

Table 1.1 Comparison of Pure Phase Aqueous Solubility with Concentrations in Groundwater Samples - Selected VOCs

Compound	Pure Phase Aqueous Solubility at 25°C[1] (mg/L)	Highest Concentration Detected in Groundwater (mg/L)	Ratio Groundwater/Aqueous Solubility (%)
Carbon Tetrachloride	793	100.0	12.6
Chloroform	7,920	49.0	0.62
cis-1,2-dichloroethene	3,500	2.9	0.83
Methylene Chloride	13,000	35.0	0.27
Tetrachloroethene (PCE)	200	20.0	10.0
Trichloroethene (TCE)	1,100	4.6	0.42

[1] = EPA, 1996. Soil Screening Guidance: Technical Background Document

Artificial fill is present directly beneath the 903 Pad and on the surface of the Lip Area as a result of previous remediation activities. In November 1968 "slightly contaminated" soil was graded from outside the fence at the 903 Pad into the fenced area to be capped. In September of 1969 a base coarse material (artificial fill) overlay, soil sterilant, and asphalt primer were placed over the 903 Pad as a "containment barrier." The asphalt pad was constructed in October of 1969 and is reportedly 7.6 cm (3 in) thick. The thickness of the base coarse materials beneath the 903 Pad is assumed to be approximately 20 cm (8 in). In February 1970, operations were initiated to apply additional fill (base coarse) over the Lip Area due to surficial radiological contamination. This fill material ranges from 2 cm (0.8 in) to 13 cm (5.1 in) (DOE, 1995a).

The surficial soil contaminants of concern are $^{239/240}Pu$ and ^{241}Am (DOE, 1995a). $^{239/240}Pu$ is relatively insoluble and tends to be strongly absorbed to fine grained soil particles. The OU2 RFI/RI (DOE, 1995a) states that 90% of the ^{241}Am and $^{239/240}Pu$ activities are concentrated in the upper 15 cm (6 in) of the soil. While there is a tendency for ^{241}Am and $^{239/240}Pu$ activities to decrease with increasing distance from the source area, isolated areas in the Americium Zone show higher activities than the 903 Pad and Lip Area.

Subsurface soil contaminants of concern include carbon tetrachloride, tetrachloroethene, trichloroethene, ^{241}Am and $^{239/240}Pu$ (DOE, 1995a). VOC concentrations observed in groundwater indicate that a DNAPL may be present beneath the 903 Pad area. The exact location of the DNAPL has not been identified from previous investigations which have included boreholes and soil gas vapor studies. It is unknown if the DNAPL has remained in the soil pore space as residual contamination, is present on the bedrock surface, or is completely dissolved in the local groundwater.

Conceptual Model - Based on the existing data and geologic setting, a conceptual model for the Investigation Area was developed. The contaminants present in the surface and subsurface soil are primarily a result of drum storage in the 903 Pad and Lip Area. Drums containing plutonium- and uranium-contaminated volatile organic compounds leaked. The liquids from the drums have moved downward towards the bedrock surface, possibly carrying a fraction of the radionuclides into the subsurface along preferential pathways such as rodent holes, desiccation cracks, and/or along decayed roots. High winds and heavy rains spread the surficial radiological contamination outward from the 903 Pad, depositing it on surface soils in the Lip Area and Americium Zone.

Previous HPGe surveys from the study area and surface soil sample data show that, in general, higher concentrations are present near the 903 Pad, and concentrations decrease with increasing distance from the 903 Pad. Immediately east and south of the 903 Pad and Lip Area, there are areas of higher concentrations which may be the result of rain and surface water dispersion of contaminants (DOE, 1995a). Accounting for the surface soil and HPGe sampling already collected from the 903 Pad area to Indiana Street, and the direction of surface water flow from the 903 Pad towards Woman Creek, it was concluded that hot spots are not likely to be present to the east, outside of the Investigation Area.

The subsurface DNAPL contamination is suspected to be present directly beneath the area where drums were previously stored. The liquid contained in the drums has migrated downward towards the bedrock surface. An east-west paleochannel (medial paleoscour, Figure 3.4) is cut into the bedrock, with the greatest depth to bedrock located toward the middle of the 903 Pad. The available subsurface and groundwater data (see Section 1.2) strongly indicates that the source for DNAPL contamination is limited to the area under the present 903 Pad. The VOC contamination east of the 903 Pad is suspected to be limited to the dissolved phase in groundwater.

2.0 DATA QUALITY OBJECTIVES

The data quality objective process consists of seven distinct steps and is designed to be iterative; the outputs of one step may influence prior steps and cause them to be refined. Each of the seven steps are described below for the Investigation Area (Figure 1.2).

2.1 State the Problem

2.1.1 Surface Soils

Previous investigations in the Lip Area and Americium Zone have revealed radiological contamination in surface soils exceeding RFCA Tier I soil action levels triggering an action. The exposure area (EA) of previous investigations were 2.5- and 10-acre plots. The purpose of this characterization effort is to further refine the volume of soils exceeding RFCA Tier I soil action levels. The volume estimate calculated from data generated from this investigation will be used for input for a remedial alternative analysis.

Asphalt and Artificial Fill - Remediation of subsurface soils at the 903 Pad may require the removal and disposal of the asphalt and artificial fill comprising the 903 Pad. Low-level waste disposal facilities require that waste be characterized, specifically that the 90% upper confidence limit of the mean be compared to waste acceptance criteria (WAC) thresholds for the contaminants of interest. No data, with the exception of a 903 Pad surface gamma survey (Rutherford, 1981), currently exists for the asphalt and artificial fill. Preliminary analytical data, specifically the mean activity and sample variance, will be required to design a statistically based sampling plan to adequately characterize the asphalt and artificial fill to meet the WAC of waste disposal facilities qualified to accept the waste.

2.1.2 Subsurface Soils

Radionuclide Contamination - Historical data from the 903 Pad indicate radionuclide activities above background in soils to 66 cm (26 in) below the asphalt pad, however, an evaluation of OU2 RFI/RI borehole data reveal no subsurface soil samples exceeded the Tier I soil action levels. Because radionuclides are suspected to have been transported with the solvents released at the 903 Pad, additional data are needed to resolve this discrepancy and to determine the depth of radiological contamination. Data collected will be compared to RFCA Tier I soil action levels.

Evaluations of the OU2 Phase II RFI/RI (DOE, 1995a) surface soil data indicated 5 Plots (Figure 1.5), each with an area of 2.5-acres, exceeded the RFCA Tier I soil action levels. The soil samples used for the evaluation were collected to 0.64 cm and 5.1 cm (0.25 in and 2.0 in) depth using the CDH and RF sampling methods, respectively. Resolution of the vertical extent of contamination is currently inadequate for soil volume estimates and related remediation costs. Therefore, determination of the extent of radiological contamination at a large scale is required to determine the volume of soils exceeding Tier I soil action levels for remedial alternative analysis.

Lastly, surface soils in the Lip Area have been disturbed by historical activities associated with stabilization of radiological contamination at the 903 Pad. In 1969, contaminated surface soils in the Lip Area were graded into the 903 Pad prior to covering the soils with an asphalt cap. Subsequent to grading the Lip Area, the surface was covered in 1970 with an artificial fill to prevent wind erosion and transport of contaminated soils from the Lip Area. Previously uncharacterized contaminated soils may exist below the artificial fill. These soils are potentially contaminated above Tier I soil action levels. Artificial fill potentially covers contaminated soils in areas remediated in 1976, 1978, and 1984.

<u>VOC Contamination</u> - Existing VOC data collected from boreholes were compared to Tier I soil action levels and the results of the comparison indicate that no soil sample exceeds Tier I soil action levels. However, groundwater data indicates the potential for DNAPL. Additional information is required to determine the location and depth of VOC contamination in subsurface soils.

2.2 Identify the Decision

2.2.1 <u>Soils</u>

Decisions required to be made using the data collected for surface and subsurface soils include:

- Do activities of radiological contaminants in soils equal or exceed the RFCA Tier I Soil Action Levels, and if they do to what is the areal and vertical extent?
- Do VOCs beneath or adjacent to the 903 Pad exist at concentration equal to or exceeding the Tier I soil action levels, and if present what is the areal and vertical extent?

Actions based on the decisions include an evaluation, remedial action, or management action of soils identified as exceeding Tier I soil action levels or other action levels identified as being protective of surface water. Final remedial actions or no further action determinations will be incorporated into the Buffer Zone OU Record of Decision (ROD).

2.2.2 Asphalt and Artificial Fill

The decisions to be made based on the asphalt and artificial fill sampling are: is the sample variance and mean values calculated from sample results collected per this SAP demonstrate adequate characterization and potential treatment of the 903 Pad asphalt and artificial fill to meet a waste disposal facilities WAC requirements.

2.3 Identify Inputs to the Decision

2.3.1 Soils

Inputs to the decision include radiochemical and chemical results from surface and subsurface soil samples for comparison to RFCA Tier I action levels. The parameters of interest include the activity/concentrations of the following radionuclides/contaminants in surface and subsurface soils:

- $^{239/240}Pu$;
- ^{241}Am;
- Uranium-234 (^{234}U);
- Uranium-235 (^{235}U);
- Uranium-238 (^{238}U); and
- VOCs (subsurface soils only).

Field sampling techniques and analytical methods were selected to collect the necessary data to compare to RFCA Tier I action levels. Methods with quantitation limits (organics) and minimum detectable activities (MDA) below action level thresholds were selected. Table 2.1 provides mid-range quantitation limits and Tier I soil action levels for VOCs suspected to be present within the Investigation Area. Table 2.2 provides the MDAs, and RFCA Tier I soil action levels for radionuclides. The direct method (HPGe) MDA for $^{239/240}Pu$ exceeds the action level threshold, however, indirect methods (calculated from the ^{241}Am activity) will allow detection of

$^{239/240}Pu$ to approximately 7 pCi/g (assuming a $^{239/240}Pu$ to ^{241}Am activity ration of 7.0). In addition, due to masking of the ^{234}U activity by ^{238}U, the ^{234}U activity will be estimated from the ^{238}U activity (assuming equilibrium/activity ratio of 1.0). Therefore ^{234}U will have a estimated MDA equal to ^{238}U at 5 pCi/g.

Sample quantities and analytical methods are provided in Tables 3.2 through 3.5. Land survey data will also be used to control sample locations.

Asphalt and Artificial Fill - Inputs to the decision include radiochemical data to include the activities of the following radionuclides:

- ^{241}Am;
- $^{239/240}Pu$;
- $^{233/234}U$:
- ^{235}U; and
- ^{238}U.

2.4 Define the Investigation Boundaries

The investigation boundaries and rationale for the boundaries selected are detailed in Section 1.1.3 and in Figures 1.1, 1.2, 1.4, 3.1, 3.2, and 3.4.

Table 2.1 Analytical Quantitation Limits - VOCs

Compound	Tier I Action Level (mg/kg)	Method 8260B Quantitation Limit (ug/kg)
Carbon Tetrachloride	11.00	740
Chloroform	152.00	740
cis-1,2-dichloroethene	9.51	740
Methylene Chloride	5.77	740
Tetrachloroethene (PCE)	11.50	740
Trichloroethene (TCE)	9.27	740

Table 2.2 Minimum Detectable Activity - Radionuclides

Radionuclide	Tier I Soil Action Level (pCi/g)	HPGe MDA[1] (pCi/g)	Alpha Spectrometry MDA (pCi/g)
Am-241	215	1	0.3
Pu-239/240	1,429	3,500[2]	0.3
U-234	1,738	250[3]	1.0
U-235	135	0.5	1.0
U-238	586	5	1.0

[1] Minimum detectable activity of direct reading (based on 15 minute count time and a bare 75% N-type HPGe).
[2] Indirect methods (estimated from ^{241}Am) will allow detection of $^{239/240}$Pu to approximately 7 pCi/g
[3] Indirect methods (estimated from ^{238}U) will allow detection of ^{234}U to approximately 5 pCi/g

2.5 *Develop a Decision Rule*

2.5.1 Radionuclides

The decision level is based on a summary evaluation of activities of radionuclides in surface and subsurface soils as defined in RFCA (DOE, 1996). If a mixture of radionuclide contaminants a, b, c are present in the soil with activities a_a, a_b, and a_c, and if the applicable action level of radionuclide in soil, as stated in RFCA, is A_a, A_b, and A_c respectively, then the activity in the soil shall be limited so that the following relationship exists:

$$\frac{a_a}{A_a} + \frac{a_b}{A_b} + \frac{a_c}{A_c} \leq 1 \qquad \text{(Eq. 2.1)}$$

Table 2.2 provides the Tier I radionuclide soil action levels for Open Space Use (DOE, 1996a). The Tier I soil action level sum of ratios equation (in units of pCi/g) is provided below as equation 2.2.

$$\frac{\text{Am-241}}{215} + \frac{\text{Pu-239/240}}{1429} + \frac{\text{U-234}}{1738} + \frac{\text{U-235}}{135} + \frac{\text{U-238}}{586} = \text{Sum of Ratio of Tier I Action Level} \qquad \text{(Eq. 2.2)}$$

If individual radionuclide activities in surface or subsurface soils equal or exceed the RFCA Tier I soil action levels, or the sum of their respective ratios exceed 1, an evaluation, remedial action, or management action is required. If individual radionuclide activities are below the Tier I soil action levels or the sum of ratios is less than 1, or below other action levels identified as being protective of surface water, the soils will not require an accelerated action and will be addressed under the Buffer Zone OU ROD.

2.5.2 Volatile Organic Compounds

The decision level is based on concentration of volatile organic compounds in soils as defined in RFCA (DOE, 1996). If the concentration of VOCs in soils equal or exceed the RFCA Tier I soil action levels for subsurface soils, an action must be taken. Table 2.1 provides the Tier I soil action levels for VOCs suspected to be present in soils at the 903 Pad.

2.5.3 Asphalt and Artificial Fill

Waste disposal facility's WAC require generators to adequately characterize waste shipments with respect to their WAC. This sampling effort is designed to collect preliminary characterization data. These data will be evaluated statistically to determine the total number of samples required to characterize the asphalt and artificial fill. After evaluating the characterization data, additional waste characterization samples, if required, will be collected during the remediation of the 903 Pad.

2.6 Specify Limits on Decision Errors

2.6.1 Surface Soils

HPGe Survey - As discussed in Section 3.0, HPGe survey coverage will directly measure 77% of the total area surveyed with circular FOVs. The remaining 23% of the area are the non-surveyed diamond-shaped interstices between FOVs. To minimize the decision error, non-survey areas adjacent to HPGe measurements which exceed action levels will be assumed to also exceed action levels. HPGe measurements will provide *in situ* ^{241}Am, ^{235}U, and ^{238}U activities for comparison with soil sample results.

Surface Soil Samples - Six (6) selected HPGe locations will have three soil samples collected, for a total of 18 samples, from the same depth interval as the HPGe measurement for gamma and alpha spectroscopy analyses in a fixed laboratory. The isotopic results will be correlated with HPGe measurements over similar intervals. Surface soil samples for isotopic analysis will be collected from pre-determined HPGe ^{241}Am activity intervals. The upper 95% confidence limit of the linear regression between the two measurements will be determined for inclusion of radionuclide activities into the RFCA sum of ratios equation. Soil samples will consist of a set of subsamples, each weighted to represent the fraction of activity viewed by the in situ system. Samples will be collected to a depth of 5 cm, processed and analyzed using gamma spectroscopy. Laboratory results will be correlated to Insitu results integrated over the same depth for the same radionuclides.

2.6.2 Subsurface Soils

Two aspects of the subsurface soil sampling design were evaluated relative to the confidence of contamination detection and subsequent project decisions: 1) grid density/spacing; and 2) number of samples needed. The grid densities/spacings and total number of samples represent an optimum compromise between cost (restraints) and an acceptable confidence (power of 90%) of detecting contaminants of concern within the soil volumes of interest. Table 2.3 indicates the number of samples needed to provide a range of confidences that the mean value of the most toxic VOC of concern (CCl_4) is below the RFCA Tier I action level (11 mg/Kg). This calculation is based on historical subsurface soil data (DOE, 1995a) in the study area and the equation promulgated by EPA for optimizing sample quantities relative to action levels (EPA {G-4}, 1994). Lognormal transformations were performed with the G-4 calculation based on lognormality of the VOC data (specifically CCl_4 and PCE).

This SAP provides an adequate number samples to exceed a 90% confidence that mean values of VOCs are less than RFCA Tier I action levels (compare Table 3.4 sample quantities with Table 2.3). The number of radionuclide samples planned, likewise, will exceed a calculated 90% confidence level. The distribution resulting from historical subsurface radionuclides (^{241}Am in particular) was bimodal due primarily to nondetects combined with 8 samples collected immediately beneath the 903 Pad that were up to 4 orders of magnitude higher than the majority of OU-2 subsurface samples. Given this particular distribution, the calculated numbers of samples needed (Table 2.3) are semi-quantitative, but are useful as indicators (compare Table 3.5 sample quantities with Table 2.3).

Table 2.4 displays the grid density and spacing specifications for both the 903 Pad and the Lip Area. This same grid density and spacing may be used for the Americium Zone depending on the results of the HPGe survey. Systematic grid sampling was selected as the design of choice based on one of the primary objectives of this project: to estimate, with quantifiable error, the location(s) and volume of soils (surface and subsurface) that must be remediated due to contaminant levels (VOCs and radionuclides) that exceed applicable action. Statistical studies indicate that this approach is preferred over other designs for estimating means, totals, and patterns of contamination (Gilbert, 1987). Further, a systematic grid pattern is essential for quantifying the "consumer's risk" associated with the design, i.e., to address the question: What is the probability of missing contamination (consumer's risk), within the sampling boundaries, with a given size, shape, and concentration? Consumer's risk, within an environmental restoration scenario, may be thought of as the risk assumed by the public (and regulators).

Table 2.4 specifies the dimensions of areas of contamination that can be detected, and the associated risk of non-detection (Beta Error). While these dimensions may seem coarse, it should be noted that the overall number of samples taken is more than is necessary (discussed above) given the low mean values of historical data relative to current RFCA Tier I action levels Additionally, sample locations with concentrations greater than action levels will be "stepped-out" one-half the distance to the next grid node *without detection* for an additional sampling location. This optimization of the grid sampling is further discussed in Section 3.2. Relative to costs, as the grid spacing is cut in half, the number of samples roughly doubles and consequent sampling costs also roughly double; such a relationship represents the issue between improving the resolution of contaminant detection and keeping project costs under control.

Because higher concentrations and occurrences of radionuclides in the subsurface beneath the 903 Pad are anticipated (DOE, 1996, RMRS, 1997), the grid sample density for the 903 Pad is twice that of the outlying Lip Area. The radionuclide sampling program is based on the placement of 25 boreholes on a grid spacing of 75 feet over the 3.4 acre area of the 903 Pad. Consumer's risk (Beta error) is set at 10% for all grid spacing evaluations.

Table 2.3 Surface and Subsurface Soil Sample Confidence Calculations

Surface Soils, CDH Method	AM-241 (pCi/g) normal	nat log log trans	U-238 (pCi/g) normal	nat log log trans	Subsurface Soils PCE (ug/kg) normal	nat log log trans	CCl4 (ug/kg) normal	nat log log trans	AM-241 (pCi/g) normal	nat log log trans	U-238 (pCi/g) normal	nat log log trans	U-235 all <0.3 all <0.3
$(\text{std dev})^2$ =	968.3	4.5	12752.0	0.5	276.9	0.5	2035.7	1.5	141088	9.8	0.1	0.2	
N =	116	116	116	116	43	43	43	43	87	87	84	116	
Z score (85% CL)	1.035	1.035	1.035	1.035	1.035	1.035	1.035	1.035	1.035	1.035	1.035	1.035	
Z score (90% CL)	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	
Z score (95% CL)	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645	
mean	8.803006	-0.0803	12.0169	0.4145	9.97727	1.89907	23.4091	2.161	90.60264	-2.22681	0.84592	-0.2512	
Action Level (Table ES-1)	209	2.32015	506	2.70415	11500	4.0607	11000	4.04139	209	2.32015	506	2.70415	
EPA G-4, App. C													
85% CL	1	49	1	3	1	3	1	11	44	13	1	2	
90% CL	1	382	1	4	1	5	1	38	67	51	1	3	
95% CL	2	18364	2	12	1	14	1	399	110	665	1	5	

Table 2.4 Circular Contamination Geometry - Subsurface Investigation[1]

Area	Grid (ft)	Diameter (ft)	L (ft)	S	L/G	Beta Error
903 Pad	75	82	41	1	0.55	10%
Lip Area	151	166	83	1	0.55	10%

S = (length of short axis)/(length of long axis)
L = ½ length of long axis of ellipse
G - Grid Space
[1]Calculations based on Chapter 10, Gilbert, 1987.

VOC borehole location placement is based on a subjective, or "judgment", sampling design on the basis of groundwater data and areas of drum storage from aerial photographs. All areas of interest are completely accessible so that location bias is not a problem; the locations were chosen for their unique value and representation, especially groundwater contamination, rather than for drawing inferences about a wider population.

The quality control (QC) samples for the project will include a 1 in 20 frequency for duplicate samples and equipment rinsates; a trip blank will be provided for each sample shipment for VOC analysis. Relative percent difference (RPD) goals for soils will be 40% for non-organics and 30% for organics. The duplicated error ratio for radionuclides shall be 1.42. A completion goal for the project will be 90%. The completion goal means that 90% of the data collected, analyzed, and verified will be of acceptable quality for decision making. Twenty-five percent of the total analytical data will undergo validation by a third party. The remaining 75% of the data will be verified.

2.6.3 Asphalt and Artificial Fill

There will be no limits on decision errors for the asphalt and artificial fill sampling.

2.7 Optimize the Design for Obtaining Data

2.7.1 Surface Soils

This SAP will use a linear regression double sampling technique to estimate the activity of actinides in surface soils. The double sampling method (Gilbert, 1987) was selected because there is a strong linear correlation between ^{241}Am and $^{239/240}$Pu in the Investigation Area surface soils. The process flow for quality control of HPGe measurements is shown in Figure 2.1.

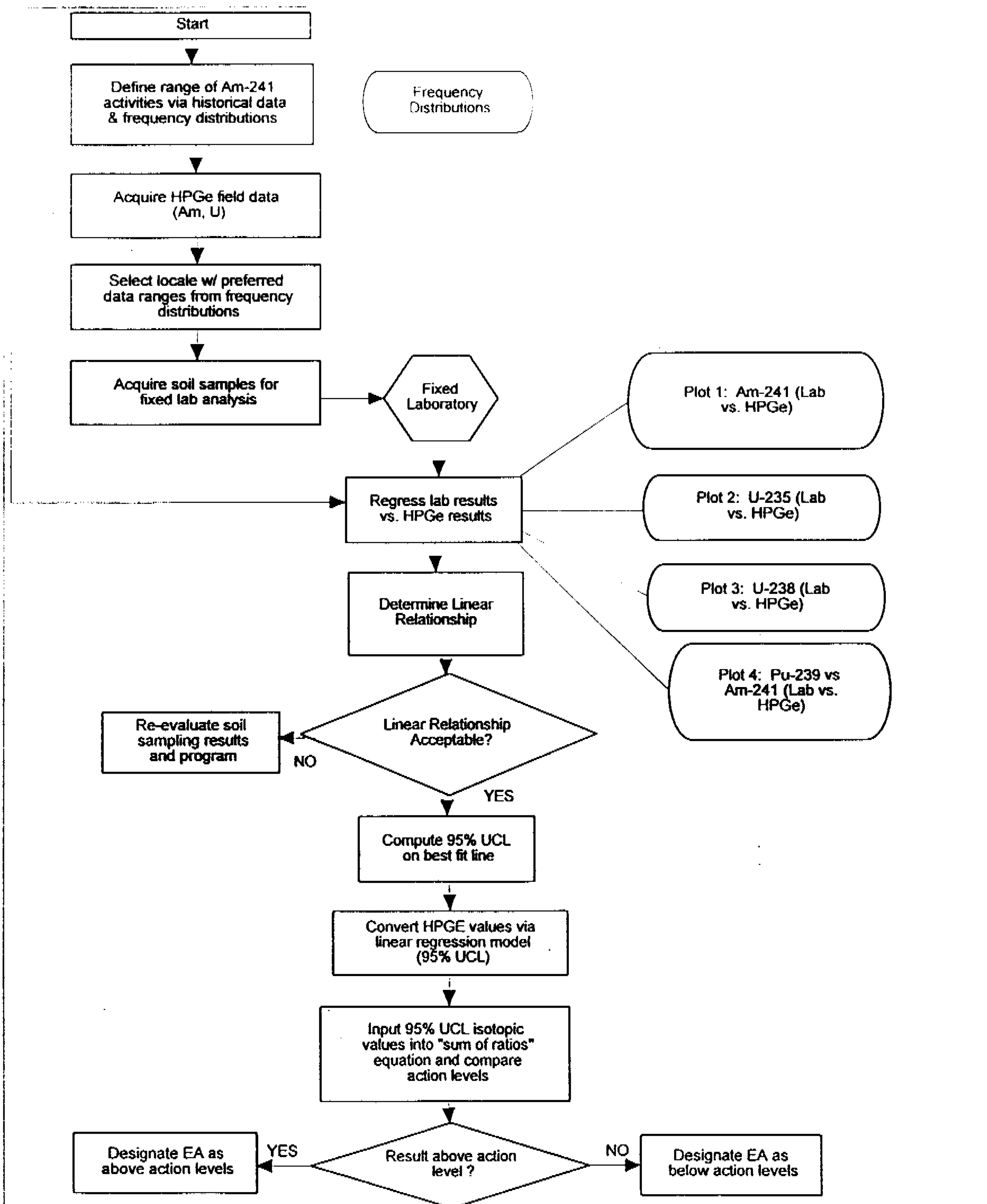


FIGURE 2.1

PROCESS FLOW FOR CORRELATION OF HPGe MEASUREMENTS TO FIXED LAB RESULTS

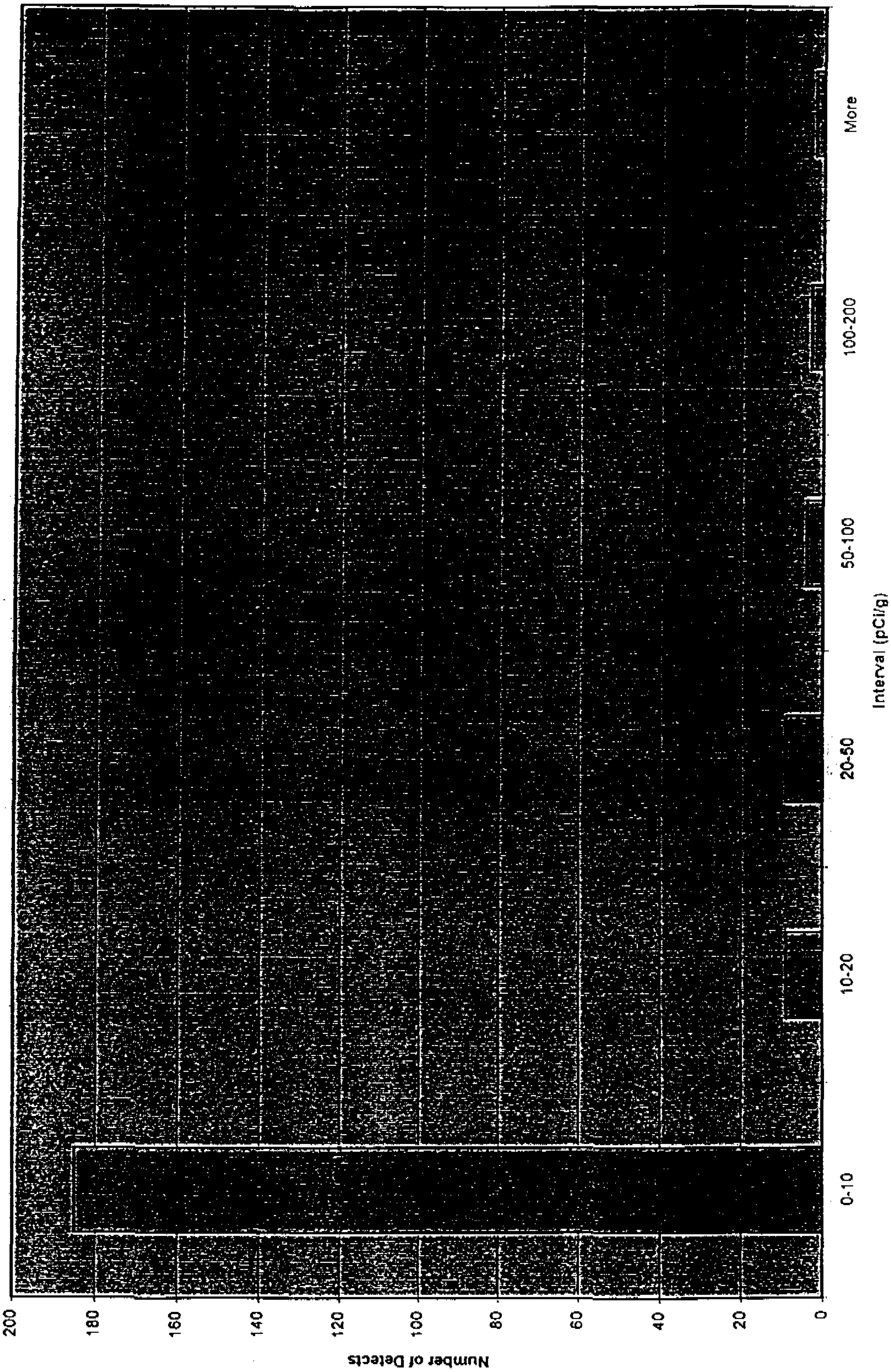
HPGe measurement will determine activities of ^{241}Am, ^{235}U and ^{238}U in surface soils. The sum of ratios equation requires input activities for ^{241}Am, $^{239/240}Pu$, ^{234}U, ^{235}U, and ^{238}U. Therefore, activities for $^{239/240}Pu$ and ^{234}U will be required to complete the sum of ratios calculation. $^{239/240}Pu$ and ^{241}Am are known to have a linear relationship and a high coefficient of correlation. Two hundred and eleven surface soil samples collected in support of the OU2 Phase II RFI/RI produced a correlation coefficient of 0.96 when $^{239/240}Pu$ was regressed from ^{241}Am. ^{241}Am activities in surface soils can be measured with less expensive *in situ* gamma-ray spectroscopy methods to determine $^{239/240}Pu$ concentration rather than $^{239/240}Pu$ concentrations determined from expensive radiochemical techniques performed in a laboratory.

The $^{239/240}Pu$ soil sample results from the laboratory and the HPGe ^{241}Am measurements will be correlated through linear regression to verify the relationship established between the two radionuclides activities from previous samplings studies. The quantitative relationship will allow determination of $^{239/240}Pu$ in soils from HPGe ^{241}Am measurements for consequent comparison with RFCA Tier I soil action levels for the Buffer Zone (hypothetical resident, 85 millirem annual dose) based on HPGe measurements alone.

Activities of ^{234}U will be determined from ^{238}U results, based on the fact that ^{234}U is in equilibrium with ^{238}U. Equilibrium between a parent (^{238}U) and daughter (^{234}U) indicates that the activity ratio between these two isotopes should be near 1.0. Analytical data collected in support of the OU2 Phase II RFI/RI CDH surface soil sampling program (DOE, 1995a) supports this relationship with an mean activity ratio of 0.97 between the two isotopes. Activities of ^{234}U will be estimated from ^{238}U results.

The OU2 Phase II RFI/RI report states that 90% of the total actinide activity is located in the top 15 cm (6 in) of soils. Further evaluation of data for soil profile Pits TR04, TR05, TR09, TR11, and TR12, all of which are located within undisturbed areas in the Investigation Area, indicates that 70 to 88% of the total actinide activity is in the upper 6 cm (2.4 in) of soils. Therefore, soil samples will be collected to a depth of 5 cm (2 in) for correlation with HPGe measurements. HPGe results will be integrated over a depth of 5 cm (2in). The 5 cm (2 in) depth was selected based on the fact a majority of the activity is in the upper 2.4 cm (1 in) and that numerous OU2 RFI/RI surface soil data, collected from 0 - 5 cm (0 - 2 in), currently exists in the study area for comparison purposes. The detection frequency of OU2 surface soil ^{241}Am is provided in

Figure 2.2
Frequency of AM-241 Detections in Surface Soils
CDH and RF Sampling Method Results



2.7.2 Subsurface Soils

Determination of the vertical and thus the areal distribution of radiological contaminants will be optimized through a "step-out" boring approach. This will be implemented by the placement of a boring half way between locations exhibiting radiological contaminants above and below Tier I soil action levels respectively. Only one "step-out" boring will be completed per original grid sample location, as needed.

Determination of the vertical and areal extent of VOC contaminants will be optimized through a "step-out" boring approach. This will be implemented by the placement of a boring upgradient of a boring with analytical results indicating VOCs are above 10 % of the RFCA Tier I action level. The sampling grid will be extended an additional 6.1 m (20 ft) in an upgradient direction (based on the potentiometric surface, [DOE, 1995]) of that location and additional samples will be collected for laboratory analysis.

3.0 SAMPLING AND ANALYSES - STRATEGY AND DESIGN

Radiological contamination in the Americium Zone surface soils will be evaluated using HPGe *in situ* gamma-ray spectrometry methodology. Subsurface soil samples will be collected to further refine the depth of radiological contamination. HPGe results will be correlated to radiochemical data by the analysis of surface soil samples collected from 6 HPGe survey measurement locations. The soil samples will be collected over the same depth interval as the HPGe measurement.

The vertical and lateral extent of radiological and VOC contamination at the 903 Pad and Lip Area will be assessed utilizing Geoprobe® or conventional hollow-stem auger drilling techniques to collect subsurface soil samples for analysis. Asphalt samples from the 903 Pad will be collected to obtain a preliminary waste characterization data for disposal purposes. Field activities will be performed in accordance with FO.1, Air Monitoring and Particulate Control.

3.1 Radiological Contamination

The areal extent of radiological surface soil contamination will be primarily assessed using a non-intrusive *in situ* gamma-ray spectrometry techniques (i.e., HPGe survey) and collection of surface soil samples for isotopic laboratory analysis for correlation of the HPGe results. Vertical and areal extent of radiological contamination will be assessed with subsurface soil samples submitted for isotopic laboratory analysis using gamma and alpha spectrometric methods. Follow-up FIDLER surveys may be performed to further refine the areal extent of radiological contamination.

3.1.1 Surface Soil Investigation

The surface soil investigations will be implemented by performing an HPGe survey and collecting surface soil samples at HPGe measurement locations with predetermined ^{241}Am activities. The soil sample results and HPGe measurement results will be correlated to estimate activities of radionuclides for input into the RFCA sum of ratios equation.

Field Preparation - Reference stakes for the HPGe grid will be placed in the field before and during data collection activities. From these stakes, the HPGe survey grid will be laid out using manual methods, at the 13 m triangular grid spacing specified below. Each measurement point will be staked, flagged, and numbered for reference by the HPGe crew.

HPGe Survey - The HPGe survey will be initiated in the Americium Zone adjacent to the Lip Area's eastern boundary in this area and proceed eastward. Subsurface soil results are required in the Lip Area prior to performing the HPGe survey. In the Lip Area it will be assumed that if subsurface soil contamination exists, the overlying surface soils will require similar remedial action and these soils and will be included into the volume estimate of soil exceeding the Tier I action level. HPGe surveys will therefore not be required in portions of the Lip Area where subsurface soils were sampled as part of this SAP. Figure 3.1 shows the configuration of a typical HPGe survey grid.

The HPGe system will be used to determine the average ^{241}Am, ^{238}U and ^{235}U activity over a FOV with a diameter of 12 meters (39.4 ft) and an area of 113 m^2 (1,217 ft^2 or 2.8 x 10^{-2} acre) with an appropriate detector height of approximately 1 m (3.28 ft) above the ground surface. Thus the EA has been defined to be single HPGe measurement with a FOV of 12 m (39.4 ft) in diameter. A 13 m triangular grid spacing to achieve 77% coverage which translates to 72 HPGe measurements for complete coverage of a 2.5-acre area. Table 3.1 provides an estimate of the number of HPGe measurements proposed in the Lip Area and Americium Zone (assuming full coverage is required).

Table 3.1 Surface Soil Investigation - Field Program

Area	HPGe Measurements (Estimated)	Surface Soil Samples[1] (Estimated)
903 Pad	0	0
Lip Area	440	0
Americium Zone	875	18 (6 locations)

[1] = A minimum of 18 surface soil samples will collected to correlate HPGe measurements.

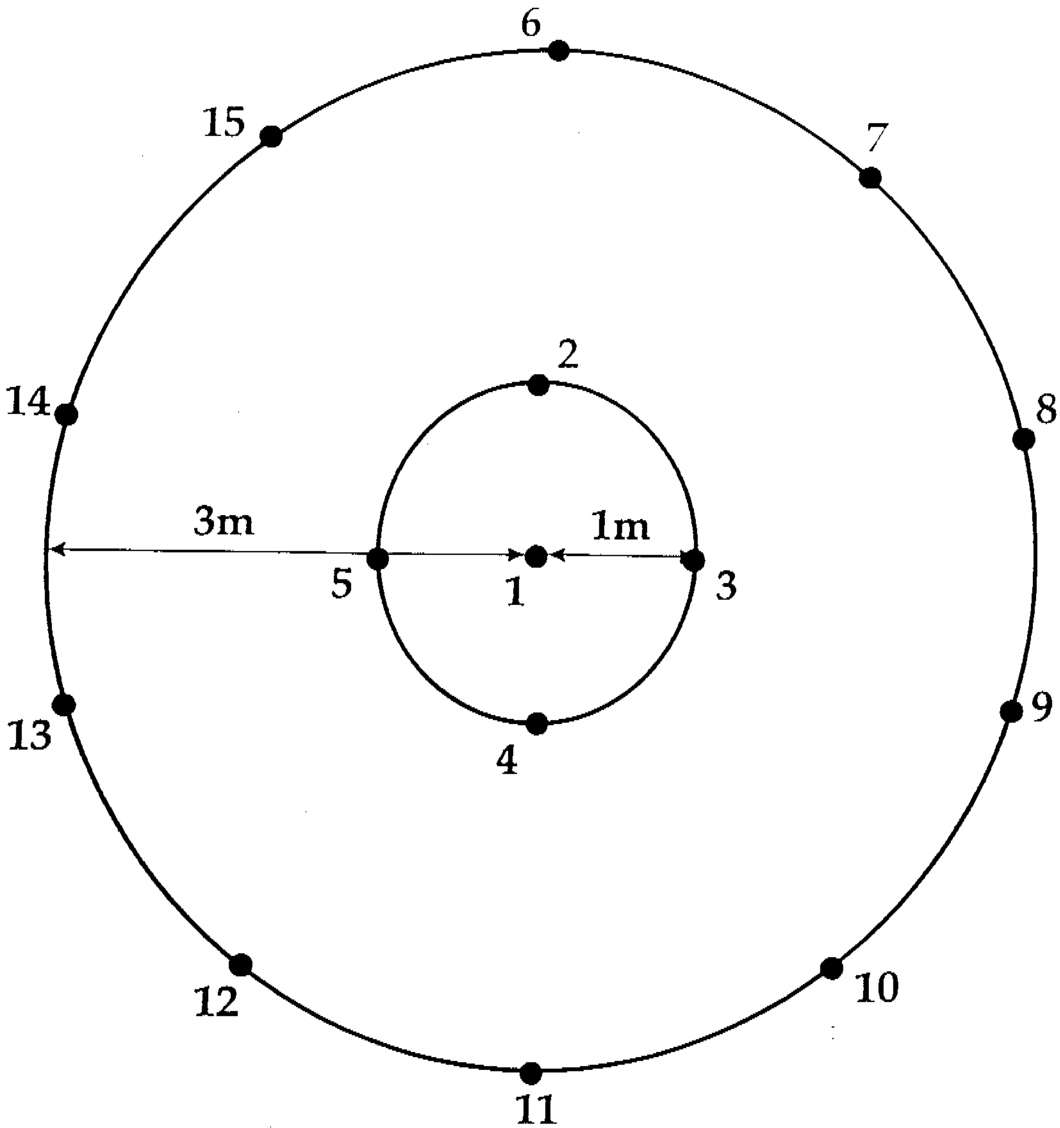
Measurement count times will be approximately 15 minutes to ensure a 95% confidence level of the HPGe to determine ^{241}Am activities in soils to 1 pCi/g. Complete HPGe coverage of the proposed Investigation Area, if required, is estimated to require approximately 1,500 measurements. The HPGe survey will be discontinued in a given direction when two consecutive and adjacent measurements are less than 10 pCi/g ^{241}Am. Soil moisture measurements will be collected from a representative area. The number of samples required will be determined based on variability of initial measurements and environmental parameters (i.e., precipitation). HPGe locations and elevations will be surveyed by land survey methods or with a Global Positioning System (GPS) operated in accordance with the manufacturers specifications.

FIDLER Surveys - A follow-on FIDLER survey may be conducted in selected areas where contiguous or isolated HPGe measurements exceed the 10 pCi/g ^{241}Am decision level . An evaluation of the nature of the exceedence will be conducted to determine if detailed FIDLER surveys are required. If an HPGe measurement for an individual FOV is above the decision level, and adjacent FOVs are below the decision level, a FIDLER survey will be conducted to determine if the high FOV measurement is caused by the presence of a smaller area containing a hot spot. In addition, detailed FIDLER surveys will be conducted at three locations where HPGe measurements for individual and surrounding FOVs exceed the RFCA Tier I action level. The purpose of the survey is to determine whether the contamination is homogeneous and widespread as suggested by the conceptual model, or heterogeneous and consists of numerous individual hot spots.

A grid with four-foot spacings will be staked in the field for the FIDLER survey. While all available data will be used to determine whether a FIDLER survey is required, it is anticipated that these will be conducted only in areas where HPGe measurements are above the decision level of 10 pCi/g, ^{241}Am. When performing a FIDLER survey, measurements will be taken with the instrument placed on the ground surface at each of the four-foot grid nodes. When walking between grid nodes, the operators will move their instruments slowly and observe the instrument response between readings. If a sharp increase in the reading is seen between grid nodes, the surrounding area will be investigated. The FIDLER surveys will be conducted in accordance with Radiological Operating Instructions (ROI) Manual, 4-H58-ROI-06.6, Use of Bicron FIDLER and will be used to locate smaller areas of increased radiological activity such as would be caused by a hot spot.

The FIDLER readings will be used to define localized areas with higher readings and will be marked as potential hot spots. Potential hot spots and areas of higher concentrations identified during the hand-held FIDLER survey will then be staked, surveyed and labeled for future evaluation. For each hot spot, additional soil samples may be collected for isotopic analysis if it is determined that this information is necessary to determine whether a remedial action is required, or to disposition the soil from a remedial action.

Surface Soil Samples - Surface soil samples will be collected using a geometry developed by the DOE (DOE, 1997b) at the Fernald Environmental Management Project site in Ohio in an effort to correlate HPGe results to surface soil results. The sampling method involves the collection of a set of soil subsamples for a given HPGe measurement FOV for laboratory analysis. The location and number of subsamples collected relative to HPGe measurements is based on the theory of *in situ* gamma-ray spectroscopy and is expected to be representative of radionuclide contamination over the FOV. Figure 3.2 provides the surface soil sampling scheme for collection of the soil sample. Up to 15 grab samples will be collected at a selected HPGe location; one grab sample from the center; four grab samples collected at 1 m radius, and ten grab samples from 3 m radius. The 1 and 3 m radius grab samples will be composited into a 1 m and 3 m sample representative of the individual band. Therefore, three separate gamma and alpha spectroscopy analyses will be performed at each selected HPGe location.



15-Point Sampling Pattern

Sampling and Analysis Plan for the Site Characterization at the 903 Drum Storage Area, 903 Lip Area and Americium Zone

Legend

● Grab Sampling Location

Figure 3.2 Surface Soil Sampling Scheme

Six (6) selected HPGe locations will have three soil samples collected, as described above for a total of 18 samples, and analyzed by gamma and alpha spectrometry to determine ^{241}Am, $^{239/240}$Pu, $^{233/234}$U, ^{235}U, and ^{238}U. The locations of soil samples will be based on the results of the HPGe measurement's ^{241}Am activity. In order to acquire a good correlation over the anticipated range of ^{241}Am activities, soil samples will be collected over six ^{241}Am activity intervals; 0-10, 10-20, 20-50, 50-100, 100-200, and greater than 200 pCi/g. These intervals were selected based on the detection frequencies of ^{241}Am from CDH and RF surface soil samples collected in support of the OU2 Phase II RFI/RI (DOE, 1995a). The detection frequency of OU2 surface soil ^{241}Am is provided in Figure 2.2. These intervals provide full coverage over the range of known activities of ^{241}Am detected in the study area.

Samples will be collected in a "bullseye" pattern to mimic the averaging done by the field HPGe detector over the FOV. The HPGe detector receives gamma-ray photons from every point within the circle; however, it receives more gamma rays from soil closer to the detector than from soil further from the detector. If the circle is divided into concentric bands, the relative weighting factor for each band can be calculated based upon the percentage influence of gamma photons at the detector which originates from a given band of soil, assuming a uniform source distribution with depth and a one MeV photon energy. The relative weighting factor is the relative importance of each band with respect to the probability of gamma-rays emitted from within that band being detected by the HPGe. The sample results are divided by the weighting factor per band, then products are summed to determine the activity of the soils in the FOV area. The 15 point sampling pattern was selected to provide adequate sampling for high and/or heterogeneous activity distributions.

Table 3.2 provide the results of these calculations and the weighting factors per sample will be used to calculate the weighted statistical data. Table 3.3 provides the analytical program for surface soil samples. The results of the HPGe measurements and soil samples will be utilized to establish the correlation between the two methods to estimate $^{239/240}$Pu activities at locations where only HPGe measurements are obtained.

Table 3.2 Surface Soil Samples, Weighted Average Calculations

No. of Subsamples	Horizontal Distance from Point Under Detector (m)	Weight (per circle)
1	0	0.1
4	1	0.36
10	3	0.54
15	Total	1.00

Table 3.3 Surface Soil/Asphalt/Artificial Fill - Analytical Program

Analytical Method	Analytes	Container	Preservative	Holding Time
Radiological Screen	Gross Alpha/Gross Beta	125-ml wide mouth glass or poly jar	None	6 months
Alpha Spectroscopy	Plutonium-$^{239/240}$, Americium-^{241}, Uranium Isotopes	125-ml wide mouth glass or poly jar for asphalt/artificial fill. 500-ml wide mouth glass of poly jar for surface soil.	None	6 months
Gamma Spectroscopy	Americium-^{241}, Uranium Isotopes	500-ml wide mouth glass of poly jar	None	6 months

Surface soil sampling locations will be selected based on the HPGe results obtained in the field. Ranges for HPGe concentrations are based on the previous HPGe ^{241}Am activities from the Americium Zone. The first sample will be collected from directly below the HPGe tripod setup location. Sampling will then proceed radially outward in the pattern as shown on Figure 3.2.

Sample locations will be pre-surveyed with the FIDLER and results recorded in the sample collection log or field logbook. Samples will be collected per GT.08, Surface Soil Sampling, Section 4.4, Soil Sampling with the Vertical Soil Profile Method, and specifically Section 4.4.6 Procedures For Coring. The RF soil sampling jig will be utilized as a template to collect the individual soil samples from 0 - 2 inches in depth. Soil samples will include all organic matter and coarse grained geologic materials (gravel size fraction or larger). Samples will be prepared in the laboratory by crushing to promote homogeneity and representativeness of the sample prior to alpha spectroscopy analysis. Soil Moisture samples will be collected from each surface soil sampling area. A single soil and air temperature measurement will be recorded for each surface soil sampling area.

Sample locations will be identified with the unique location number assigned, with indelible ink or paint pen either on a wooden lathe or pin flag. Sample locations will be surveyed for location and elevation using standard land surveying techniques or GPS receivers operated in accordance with the manufacturer's specifications.

Asphalt and Artificial Fill Samples - Asphalt and artificial fill samples from the 903 Pad will be collected to obtain preliminary estimates of the samples variance and mean for waste characterization purposes. Random sampling techniques are appropriate methods for estimating the population mean and determination of total amount of contaminants present as well as calculating the standard errors of these two estimates. A minimum of nine asphalt and artificial fill samples will be collected from sample locations randomly selected from the twenty-five 903 Pad subsurface soil sampling locations as shown in Figure 3.3. Table 3.2 provides the analytical program for asphalt and artificial fill samples.

3.1.2 Subsurface Soil Investigation

The depth of radiological contamination is required to estimate the volume of soil requiring remedial action. The depth of radiological contamination will be investigated at the: 903 Pad; Lip Area; and Americium Zone where the HPGe has identified surface soils equal to or greater than the Tier I soil action levels.

Table 3.4 provides an estimate of the number of boreholes and samples required to complete the subsurface soil investigation program. Table 3.5 provides the subsurface soil investigation analytical program. Figure 3.3 provides the radiological subsurface sampling locations for the 903 Pad and Lip Area.

903 Pad - Twenty-five shallow boreholes are proposed for the characterization of radionuclide contamination beneath the 903 Pad. Twenty-five boreholes over the 3.4-acre 903 Pad represents a borehole completed at each node of a 23 m by 23 m (75 ft by 75 ft) grid. Table 2.4 shows the diameter and error associated with detecting circular areas of contamination.

Subsurface soil samples will be collected from artificial fill material and natural soils beneath the 903 Pad for radiochemical analysis. Approximately 7.6 cm (3 in) of asphalt and 20.3cm (8 in) of artificial fill material overlie the natural soil at the 903 Pad. Soils will be continuously cored

Figure 3.3

Table 3.4 Subsurface Soil - Field Program

Area	Number of Boreholes	REAL Samples	Duplicate Samples	Rinse Samples	Trip Blanks (VOC only)	Total Samples
903 Pad	25 - Radiological Investigation	150	8	8	0	166
903 Pad	12- VOC Investigation	72 (rad)[1] 72 (VOC)[2]	4 4	4 4	0 12 (est.)	80 92
Lip Area	25-Radiological Investigation	100	5	5	0	110
Lip Area	1 - VOC Investigation	6 (rad)[1] 6 (VOC)[2]	1 1	1 1	0 1	8 9
Americium Zone	TBD[3] - Borings based on results of HPGe survey	TBD	TBD	TBD	TBD	TBD

[1] - Borehole samples collected for radiochemistry during the VOC investigation.
(est.) - estimated
[2] - Boreholes samples collected for VOC analysis during the VOC investigation.
[3] - TBD - To be determined following analysis of HPGe survey data
Approximately 373 samples will be collected for radiological screening analysis for Department of Transportation shipping requirements.

Table 3.5 Subsurface Soil - Analytical Program

Analytical Method	Analytes	Container	Preservative	Holding Time
Radiological Screen	Gross Alpha/Gross Beta	125-ml wide mouth glass or poly jar for soil, 40-ml glass for water	None	6 months
Alpha Spectroscopy	Plutonium-239/240, Americium-241, Uranium Isotopes	125-ml wide mouth glass or poly jar for soil, 1-gl poly for water	None for soil, HNO_3 for water	6 months
SW-846 Method 8260A	Volatile Organic Compounds	120-ml capped core, 125-ml wide mouth glass jar. Teflon lined closure.	Cool, 4° C	14 days
SW-846 Method 8260A (DNAPL, Trip and Rinse Blanks)	Volatile Organic Compounds	3 x 40-mL glass, Teflon lined septa cap.	Cool, 4° C HCl, pH<2	14 days

SW-846 (EPA, 1986), Test Methods for Evaluating Solid Waste.

to either a total depth of 0.92 m (3.0 ft) or 0.31 m (1.0 ft) past the depth where the FIDLER indicates less than 5,000 cpm, whichever is greater. Samples will be collected at approximately 15 cm (6 in) intervals below the asphalt or as appropriate to differentiate the sample interval between asphalt, artificial fill material, and natural soils. This will be done to prevent potential

Figure 3.4

PT016, PT019, PT020 which will be characterized under the 903 Pad subsurface radiological investigation.

Soil borings located in the Lip Area and subsurface soil samples will be collected utilizing Geoprobe® or conventional hollow-stem auguring techniques. Soils will be continuously cored to either a total depth of 0.61 m (2 ft) or 0.31 m (1 ft) past the depth where the FIDLER indicates less than 5,000 cpm, which ever is greater. Samples will be collected at approximately 15 cm (6 in) intervals or as necessary to differentiate the sample interval between artificial fill material and natural soils. This will be done to prevent potential dilution of the natural soil sample below the artificial fill material. Borings and core will be checked by engineer's tape for total depth and recovery. If necessary the borings will be overdrilled to a depth of 0.9 m (3 ft) to ensure recovery of the suspected contamination interval from 15.25 cm (6 in) to 30.5 cm (12 in). Samples for radiological screening will be collected as a composite sample from the radiological sample consisting of approximately 60 grams of soil into approximately one half of the 125 ml wide mouth sample jar. The samples will be screened for alpha, beta/gamma, and VOCs using portable field instruments. Radiological contamination is suspected from ground surface to a depth of 28 cm (11 in) based on the radiological results from Soil Profile Pit TR08.

It should be noted that if subsurface soils in the Lip Area are determined to exceed Tier I soil action levels in areas where artificial has been placed, surface soils will be assumed (for alternative analysis purposes) to also be contaminated and will require the same remedial treatment as the subsurface soils. This assumption is based on operation difficulties associated with the removal of the surface soils without introducing subsurface contaminants to them, and the probability that the surface soils in the Lip Area have been impacted by radionuclides. Detailed surface soil characterization (i.e., HPGe surveys) will not be performed in portions of the Lip Area where subsurface soils are determined to exist above Tier I action levels.

Americium Zone - Subsurface soil samples will be collected in the Americium Zone to determine the depth of radiological contamination associated with the surface soil program. The number, location, and depth of subsurface soil samples to be collected will be determined following the analysis of the HPGe survey data. The analysis of HPGe data will provide the areal extent of surface soils exceeding Tier I soil action levels. Subsurface soil samples may not be required on the basis of existing data indicating the vertical extent, estimated at 28 cm (11 in) from the OU2 data (DOE, 1995a). If required, additional subsurface soil samples in the Americium Zone may be collected using a similar systematic sampling grid and methodology as used for the Lip Area or another applicable methodology and this SAP will be modified as appropriate.

3.2 VOC Investigation

Investigation of VOC contamination at the 903 Pad will begin with the highest areas of groundwater contamination and in the Lip Area where the anomalous PCE soil gas results, east of borehole 07191, were observed. Figure 3.4 shows the proposed borehole locations for the VOC investigation. Table 3.4 provides the proposed number of boreholes to be completed and the number of samples to be collected by area. Table 3.5 provides the analytical program for subsurface soil samples collected for the VOC investigation.

Subsurface soil sampling at the 903 Pad will be implemented near existing groundwater monitoring wells 06691, and 08891 using an upgradient radial placement geometry with the well location serving as the downgradient location. Boreholes will be located 20 ft to the north, south, and west of well locations 06691, and 08891. Six boreholes will be placed along the west to northwest side of the 903 Pad on the basis of aerial photographs with drum storage and surface staining (Figure 3.4). These locations will utilize the same grid spacing/locations from the subsurface radiological investigation from Figure 3.3. The number of boreholes required to investigate the VOC contamination at the 903 Pad are based on the initial 12 boreholes. Approximately eight additional "step-out" boreholes may be required to characterize contamination at the 903 Pad.

The soil gas anomaly in the Lip Area at the southeast corner of the 903 Pad adjacent to borehole 07191 will be evaluated. One borehole will be spotted with a center 20 ft east and 10 ft south of borehole location 07191. VOC contamination was not detected in subsurface soil samples from borehole 07191.

Boreholes will be advanced from the ground or asphalt surface either to a depth of 0.31 to 0.62 m (1 to 2 feet) below the top of bedrock or 0.31 to 0.62 m (1 to 2 feet) below the vertical extent of VOC contamination (based on field instruments), whichever is greater. Samples will be collected at 1.22 m (4 ft) intervals below ground surface, or at intervals where VOCs are detected with field instrumentation. The VOC sample will be collected from approximately the lower 15 cm (6 in) interval and the radiological sample will be collected from the 15 cm (6 in) interval above the VOC sample. Samples for radiological screening will be collected as a composite sample from the radiological sample consisting of approximately 60 grams of soil into approximately one half of the 125 ml wide mouth sample jar. Because of the different ionization potential between PCE and CCl_4, two photoionization detectors will be used (10.4 and a 11.7 eV bulb). If VOCs are detected above 10 % of the RFCA Tier I action levels, then the sampling grid will be extended an additional 6.1 m (20 ft) in an upgradient direction of that location, and additional samples will be collected for laboratory analysis.

If DNAPL is encountered, the follow-up boring step-out distance will be reduced to 3 m (10 ft). If DNAPL is suspected, an attempt to collect a liquid sample from the core barrel will be made and the borehole will proceed no more than approximately 0.61 m (2 ft) into bedrock. This process will continue until the area of contamination is defined. Follow-up borehole locations will be relocated in the field based on analytical results (i.e. if areas of VOC contamination are observed as compared to the RFCA Tier I action levels, additional borehole locations for soil sampling may be required to further delineate the extent of contamination).

A surface area with little or no vegetation and FIDLER readings greater than 10,000 cpm was identified 30 feet east of well 6591, adjacent to the west side of the 903 Pad. One of the west VOC and shallow radiological boreholes will be relocated to the west to evaluate this area. The radiological sampling methodology described above for the Lip Area radiological subsurface investigation and the VOC sampling methodology, as described above, will be followed for this borehole.

3.3 Sample/Data Collection and Handling

Prior to implementation of the field program, Environmental Approval Process for Construction/Excavation Activities (1-F20-ER-EMR-EM.001) will be completed. Information collected in the field will be recorded in the field logbook per ADM.05.14, Use of Field Logbooks and Forms.

3.3.1 Sample and Data Collection

Surface Soils - HPGe measurements will be made at each survey location in accordance with Radiological Engineering Procedures. FIDLER surveys will be conducted in accordance with ROI Manual, 4-H58-ROI-06.6, Use of Bicron FIDLER. Surface soil samples will be collected utilizing the RF method, as modified by this SAP (Section 3.1.1), identified in GT.08, Surface Soil Sampling.

Subsurface Soils - The vertical extent of contamination shall be investigated through the completion of boreholes. Borehole locations shall be cleared according to GT.10, Borehole Clearing. Pre-work FIDLER surveys will be performed at borehole locations in the Lip Area per ROI Manual, 4-H58-ROI-06.6, Use of Bicron FIDLER Borehole locations in the Lip Area may be adjusted on the basis of the pre-work FIDLER surveys with greater than 10,000 cpm. Boreholes will be completed by procedure GT.02, Drilling and Sampling Using Hollow-Stem Auger Techniques, or by GT.39, Push Subsurface Soil Sample. If hollow-stem auger techniques are selected, soil samples will be collected utilizing either continuous core auger sampling or continuous drive sampling, depending on which method provides the best percentage of core recovery. Soil cores will be screened with field instruments per FO.15, Photoionization Detectors and Flame Ionization Detectors. A modified field form has been generated (Appendix A, Form ALLSURV5.XLS) which combines "Daily Field Activity Report" per GT.39, Push Subsurface Soil Sample, and Field Monitoring Results of Cuttings or Core (Form FO.8A) per FO.08, Monitoring and Containerization Drilling Fluids and Cuttings, to accommodate the additional field readings required. Boreholes will be logged according to procedure GT.01, Logging Alluvial and Bedrock Material. Boreholes will be abandoned by procedure GT.05, Plugging and Abandonment of Boreholes, except that geoprobe boreholes will be backfilled with powdered or granular bentonite from ground surface and not tremmied. Boring locations will be identified with their unique location number assigned and surveyed for location and elevation using GPS receivers or equivalent equipment.

3.3.2 Sample Handling

The location and depth interval of surface or subsurface media, either soil or water, recovered during the course of this investigation will be recorded in the field log book. RFEDS location codes will be cross indexed to appropriate sample location designations in the field logbook. Soil core and other material that is subject to only field screening will be identified by the sample location code and depth interval where the sample is obtained. Samples undergoing VOC or radioisotope analysis will have Kaiser Hill-Analytical Services Division (KH-ASD) sample numbers and labels applied to the container in the field. A sample collection form was prepared

(Appendix A, Form ER-IHSS-112/155-LB-98-381) to facilitate the documentation and correlation of the type of sample analysis, quality control samples, and radiological screening samples. A block of location codes will be of sufficient size to include the entire number of possible locations scheduled and an additional twenty percent for potential additional locations. The KH-ASD database system (AST) will be used to manage the analytical data from the laboratories which in turn will be accessed by the RMRS Soil and Water Database for management and archival. Sample collection and handling will follow procedure RMRS/OPS-PRO.069, Containing, Preserving, Handling, and Shipping Soil and Water Samples. Radioactive samples (equal to or greater than 2 nCi/g) will be transported to offsite laboratories in accordance with hazardous waste transportation shipping requirements (49CFR 172, 172.101, 173.403, and 173.421) with the appropriate shipping memo. Soil samples with greater than 6,000 to 8,000 cpm on the FIDLER are suspected to be characterized as US Department of Transportation radioactive material (potentially greater than 2,000 pCi/g gross alpha/beta total activity). Approximately 30 grams of soil sample will be collected for isotopic analysis and placed into pre-weighed sample container. The sample container containing the soil will be weighed to confirm approximately 30 grams of soil in the sample container. A FIDLER reading of the soil sample in the sample container will be recorded in the field logbook to confirm the radiological screen and isotopic results.

3.4 Equipment Decontamination/Waste Handling

Reusable sampling equipment will be decontaminated in accordance with procedure FO.03, Field Decontamination Procedures. Decontamination waters generated during the project will be managed according to procedure FO.07, Handling of Decontamination Water and Wash Water with the exception that the water will be transferred directly to the Consolidated Water Treatment Facility. Drilling equipment will be decontaminated between work areas using procedure FO.04, Decontamination of Equipment at Decontamination Facilities.

Drill cuttings will be handled in accordance with FO.08, Handling and Containerizing Drilling Fluids and Cuttings. Returned sample media will be managed in accordance with FO.09, Handling of Residual Samples. Containers will be labeled in compliance with FO.10, Receiving, Marking and Labeling Environmental Containers. Waste containers will be managed by procedure FO.23, Management of Soil and Sediment Investigative Derived Materials (IDM) and

FO.29, Disposition of Soil and Sediment Investigation-Derived Materials. Personal protective equipment shall be disposed according to procedure FO.06, Handling of Personal Protective Equipment. In the event that hazardous, low level, or mixed wastes are generated project waste generators will be responsible for insuring that the waste containers are properly filled, labeled, and have the waste residue traveler documentation in accordance with plant procedures (1-C88-WP1027-NONRAD, "Non-Radioactive Waste Packaging"; 1-M12-WO4034, "Radioactive Waste Packaging Requirements"; 4-099-WO-1100, "Solid Radioactive Waste Packaging"; 1-C80-WO-1102-WRT, "Waste/Residue Traveler Instructions"; 1-PRO-079-WGI-001, "Waste Characterization, Generation, and Packaging; and the WSRIC for Operable Unit Operations, "Version 6.0, Section No. 1, PADC-96-00003).

4.0 PROJECT ORGANIZATION

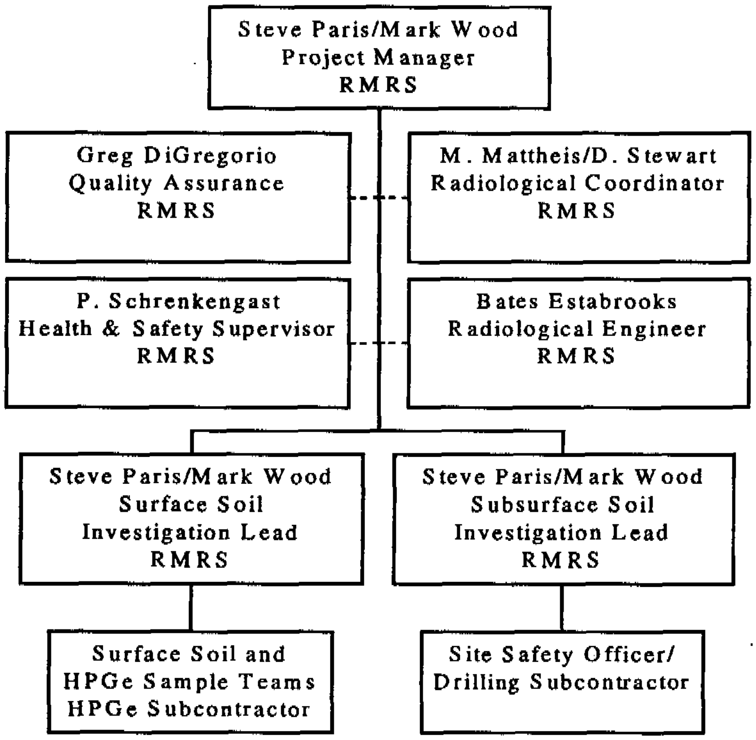
Figure 4.1 illustrates the project organizational structure. The RMRS Environmental Restoration Projects Group project manager will be the primary point of responsibility for maintaining data collection and management methods that are consistent with site operations. Other organizations assisting with the implementation of this project are: RMRS Groundwater Operations, RMRS Health and Safety, RMRS Quality Assurance, RMRS Radiological Engineering, RMRS Radiological Operations, and KH-ASD.

The sampling personnel will be responsible for field data collection, documentation, and transfer of samples for analysis. Field data collections will include sampling and obtaining screening results. Documentation will require detailed field logs and completing appropriate forms for data management and chain-of-custody shipment. The RMRS project manager will coordinate sample shipment for on-site and off-site analyses through the ASD personnel. The sampling manager is responsible for verifying that chain-of-custody documents are complete and accurate before the samples are shipped to the analytical laboratories.

5.0 QUALITY ASSURANCE

All components and processes within this project will comply with the RMRS Qualify Assurance Program Description RMRS-QAPD-001, 1/1/97 which is consistent with the K-H Team QA Program (K-H, 1997). The RMRS QA Program is consistent with quality requirements and guidelines mandated by the EPA, CDPHE and DOE. In general, the applicable categories of quality control are as follows: Quality Program; Training; Quality Improvement; Documents and Records; Work Processes; Design; Procurement; Inspection/Acceptance Testing; Management Assessments; and Independent Assessments.

Figure 4.1
903 Pad, 903 Lip Area, and Americium Zone
Organizational Chart



The project manager will be in direct contact with QA to identify and correct issues with potential quality affecting issues. Field sampling quality control will be conducted to ensure that data generated from all samples collected in the field for laboratory analysis represent the actual conditions in the field. The confidence levels of the data will be maintained as described in Section 2.0 by the collection of QC and duplicate samples, equipment rinsate samples, and trip blanks.

Duplicate samples will be collected on a frequency of one duplicate sample for every twenty real samples. Rinsate samples will be generated at a frequency of one rinsate sample for every 20 real samples collected. Trip blanks will accompany each shipment of VOC samples generated for the project. Trip blanks will not be required for samples shipped for radiochemical analysis only. Data validation will be performed on 25% of the laboratory data according to the Rocky Flats ASD, Performance Assurance Group procedures. Samples will be randomly selected from adequate surface and subsurface sample sets (RINS) by ASD personnel to fulfill data validation of 25% of the total number of VOC and radioisotopic analyses. Table 5.1 provides the QA/QC samples and frequency requirements of QA sample generation.

Analytical data that is collected in support of the of the 903 Pad SAP will be evaluated using the guidance developed by the Rocky Flats Procedure RF/RMRS-98-200, Evaluation of Data for Usability in Final Reports. This procedure establishes the guidelines for evaluating analytical data with respect to precision, accuracy, representativeness, completeness, and comparability (PARCC) parameters.

Table 5.1 QA/QC Sample Type, Frequency, and Quantity

Sample Type	Frequency	Comments	Quantity (estimated)
Duplicate	One duplicate for each twenty real samples		25
Rinse Blank	One rinse blank for each twenty real samples	To be performed with reusable sampling equipment following decontamination procedures	25
Trip Blank	One trip blank per shipping container	VOC analysis shipments only	25

Analytical data that is collected in support of the of the 903 Pad SAP will be evaluated using the guidance developed by the Rocky Flats Administrative Procedure 2-G32-ER-ADM-08.02, Evaluation of ERM Data for Usability in Final Reports. This procedure establishes the guidelines for evaluating analytical data with respect to precision, accuracy, representativeness, completeness, and comparability (PARCC) parameters.

A definition of PARCC parameters and the specific applications to the investigation are as follows:

Precision - A quantitative measure of data quality that refers to the reproducibility or degree of agreement among replicate or duplicate measurements of a parameter. The closer the numerical values of the measurements are to each other, the lower the relative percent difference and the greater the precision. The relative percent difference (RPD) for results of duplicate and replicate samples will be tabulated according to matrix and analytical suites to compare for compliance with established precision DQOs. Specifications on repeatability are provided in Table 5.2. Deficiencies will be noted and qualified, if required.

Accuracy- A quantitative measure of data quality that refers to the degree of difference between measured or calculated values and the true value of a parameter. The closer the measurement to the true value, the more accurate the measurement. The actual analytical method and detection limits will be compared with the required analytical method and detection limits for VOCs and radionuclides to assess the DQO compliance for accuracy. Sensitivities of analytical and radiochemical methods scheduled are listed in Tables 2.1 and 2.2.

Representativeness - A qualitative characteristic of data quality defined by the degree to which the data absolutely and exactly represent the characteristics of a population. Representativeness is accomplished by obtaining an adequate number of samples from appropriate spatial locations within the medium of interest. The actual sample types and quantities will be compared with those stated in the SAP or other related documents and organized by media type and analytical suite. Deviation from the required and actual parameters will be justified.

Completeness - A quantitative measure of data quality expressed as the percentage of valid or acceptable data obtained from a measurement system. A completeness goal of

90% has been set for this SAP. Real samples and QC samples will be reviewed for the data usability and achievement of internal DQO usability goals. If sample data cannot be used, the non-compliance will be justified, as required.

Comparability - A qualitative measure defined by the confidence with which one data set can be compared to another. Comparability will be attained through consistent use of industry standards (e.g., SW-846) and standard operating procedures, both in the field and in laboratories. Statistical tests may be used for quantitative comparison between sample sets (populations). Deficiencies will be qualified, as required. Quantitative values for PARCC parameters for the project are provide in Table 5.2.

Laboratory validation shall be performed on 25% of the characterization data collected in support of this project. Laboratory verification shall be performed on the remaining 75% of the data. Data usability shall be performed on laboratory validated data according to procedure 2-G32-ER-ADM-08.02, Evaluation of ERM Data for Usability in Final Reports.

Table 5.2 PARCC Parameter Summary

PARCC	Radionuclides	Non-Radionuclides
Precision	Duplicate Error Ratio ≤ 1.42	RPD ≤ 30% for Organics RPD ≤ 40% for Non-Organics
Accuracy	Detection Limits per method and APO Laboratory SOW. HPGe Detection limits per Technical Basis Document and per SAP	Comparison of Laboratory Control Sample Results with Real Sample Results
Representativeness	Based on SOPs and SAP	Based on SOPs and SAP
Comparability	Based on SOPs and SAP	Based on SOPs and SAP
Completeness	90% Useable	90% Useable

6.0 SCHEDULE

Subsurface soil field activities are scheduled to begin in February with an expected completion in October 1998. Surface soil field activities are scheduled to begin in September with an expected completion in November 1998. A data summary report is expected to be completed by August 1999.

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APPENDIX A

FIELD FORMS

IHSS 112/155 SAMPLE COLLECTION FORM **LOGBOOK: ER-IHSS-112/155-LB-98-381**

DATE:________________ INVESTIGATION AREA:________________

RIN#: 98A______________ SAMPLERS:________________________ QC/PEER REVIEW:____________________________
Print/Sign/Date

Time	Event	Bottle	Analysis	Location Code	QC	Assoc. RadS Event/Bottle	Assoc. QC Event/Bottle	Empty WT	Full WT	Sample Weight	Total Activity
			VOA Rad RadS		Real TB Rns DUP						
			VOA Rad RadS		Real TB Rns DUP						
			VOA Rad RadS		Real TB Rns DUP						
			VOA Rad RadS		Real TB Rns DUP						
			VOA Rad RadS		Real TB Rns DUP						
			VOA Rad RadS		Real TB Rns DUP						
			VOA Rad RadS		Real TB Rns DUP						
			VOA Rad RadS		Real TB Rns DUP						
			VOA Rad RadS		Real TB Rns DUP						
			VOA Rad RadS		Real TB Rns DUP						
			VOA Rad RadS		Real TB Rns DUP						
			VOA Rad RadS		Real TB Rns DUP						
			VOA Rad RadS		Real TB Rns DUP						
			VOA Rad RadS		Real TB Rns DUP						
			VOA Rad RadS		Real TB Rns DUP						
			VOA Rad RadS		Real TB Rns DUP						
			VOA Rad RadS		Real TB Rns DUP						
			VOA Rad RadS		Real TB Rns DUP						

PROJECT NAME :
LOCATION CODE :
DRIVING CO :
DRIVER :

GEOLOGIST:
TOTAL DEPTH (FT) :
SUBCONTRACTOR :
RIG TYPE :

DRIVING METHOD :
DRILLING FLUID :
BIT DIAMETER (IN.) :
CREW MEMBER (S) :

ALLSURV5.XLS

WIND DIRECTION	WIND SPEED MPH	BORE HOLE#	TIME	TYPE OR EQUIPMENT	ACTUAL DEPTH IN FEET	ACTUAL CORE RECOVERY IN FEET	BKG MINI RAE (11.7) PPM	BZ MINI RAE (11.7) PPM	DIRECT READ MINI RAE (11.7) PPM	FOXBRO TVA BKG PID(10.6) READ PPM	FOXBRO TVA HEAD SPACE PID(10.6) READ PPM	FOXBRO TVA DIRECT PID(10.6) READ PPM	MINI RAM :DUST	ELECTRA DIRECT ALPHA CPM FIXED	ELECTRA DIRECT BETA GAMMA CPM FIXED	FIDLER CPM	OUTSIDE TEMP	HEAT STRESS WBGT OR WIND CHILL
				GEOPROBE ROD	0.0-0.5													
				ROD	0.5-1.0													
				CUTTING SHOE	1.0-1.5													
					1.5-2.0													
					2.0-2.5													
					2.5-3.0													
					3.0-3.5													
					3.5-4.0													
					4.0-4.5													
					4.5-5.0													
					5.0-5.5													
					5.5-6.0													
					6.0-6.5													
					6.5-7.0													
					7.0-7.5													
					7.5-8.0													
					8.0-8.5													
					8.5-9.0													
					9.0-9.5													
					9.5-10.0													
					10.0-10.5													
					10.5-11.0													
					11.0-11.5													
					11.5-12.0													
					12.0-12.5													
					12.5-13.0													
					13.0-13.5													
					13.5-14.0													
					14.0-14.5													
					14.5-15.0													
					15.0-15.5													
					15.5-16.0													

END OF THE DAY STATUS: IN PROGRESS ______ DRILLING COMPLETED ______

CHRONOLOGICAL RECORD OF ACTIVITIES AND COMMENTS

WAS THERE FLUID IN HOLE AT THE BEGINNING OF THE DAILY OPERATIONS ?

IF YES, WHAT WAS WATER LEVEL ? ______ Ft. YES ______ NO ______

WEATHER :

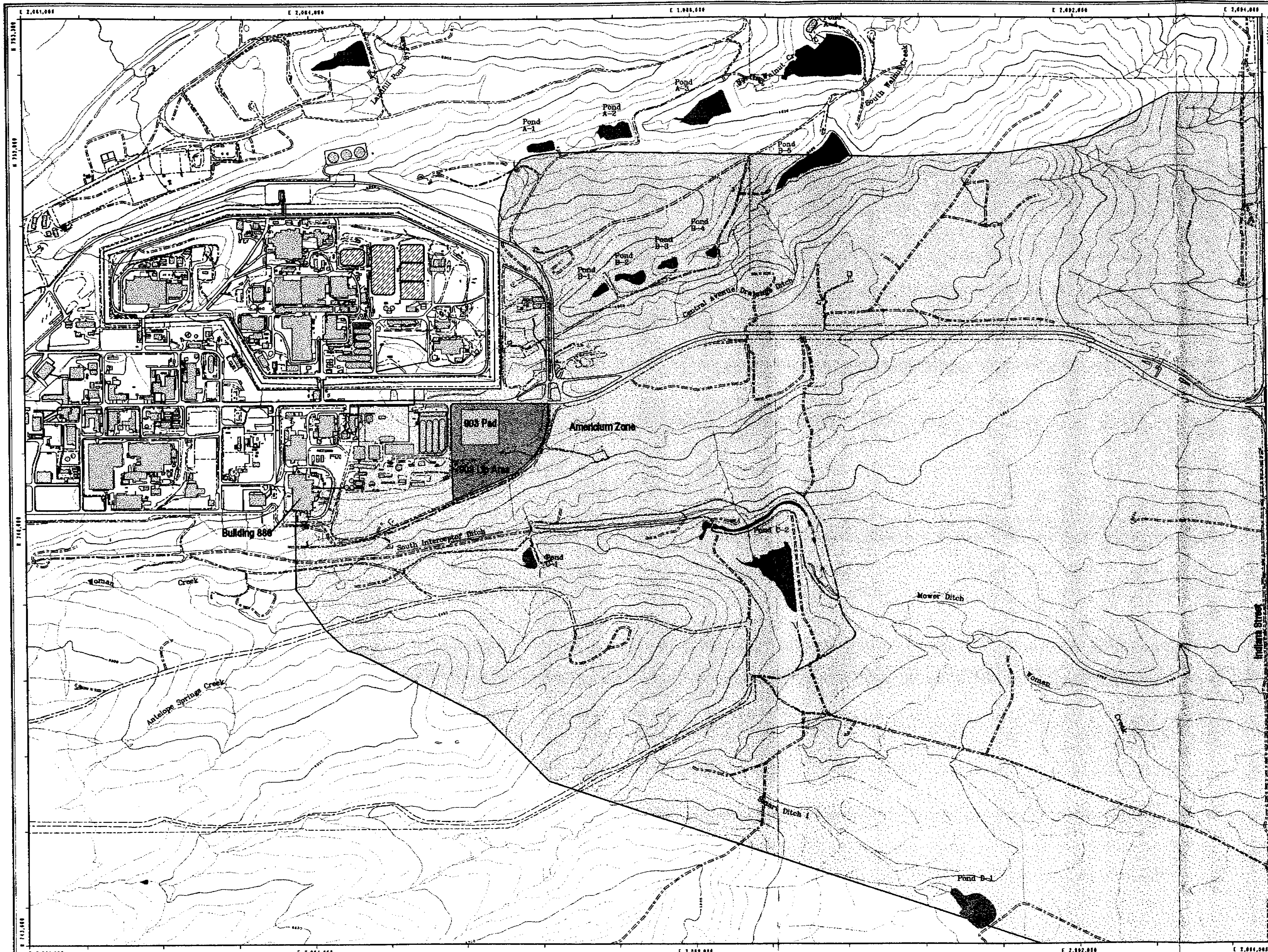
COMPLETED BY : ______ DATE: ______

PRINT NAME SIGNATURE

CHECKED BY: ______ DATE: ______

PRINT NAME SIGNATURE

Manufacture and Model #	Serial #	Probe Type	Probe #	Cal Due
MINI RAM PDM3	5345	N/A	N/A	8/4/98
MINI RAE 11.7 (E)	OOO120	N/A	N/A	2/5/99
MINI RAE 11.7		N/A	N/A	
FOXBORO PID/FID	17192120	N/A	N/A	12/5/98
BICRON ANALYST	A051M	FIDLER	A051M	6/26/98
BICRON ANALYST	BO89G	FIDLER	B891G	11/13/98
LUDLUM 2929	99057	43-10-1	97836	7/28/98
LUDLUM 2929	99042	43-10-1	97837	7/28/98
LUDLUM 2929	111573	43-10-1	114341	7/8/98
ELECTRA 1B	1848	DP6B	1030	4/9/98
ELECTRA 1B	1271	DP6B	1038	5/19/98
ELECTRA 1B	1261	DP6B	1023	7/19/98



Sampling and Analysis Plan for the Site Characterization of the 903 Drum Storage Area, 903 Lip Area and Americium Zone

Study Area Location Map
Figure 1.1

EXPLANATION

- 903 Lip Area
- Study Area
- 903 Pad

Standard Map Features

- Buildings and other structures
- Solar evaporation ponds
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Contour (20-Foot)
- Paved roads
- Dirt roads

DATA SOURCE:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas.
Digitized from the orthophotographs. 1/95
Topography (contours) were derived from digital elevation model (DEM) data by [illegible] (MK) using ESRI Arc TIN and LATTICE to process the DEM data to create 5-foot contours.
The DEM data was capture by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at 10 (?) meter resolution.
The DEM post-processing performed by MK, Winter 1997.

N

Scale = 1 : 11890
1 inch represents approximately 991 feet

250 0 500 1000Ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:

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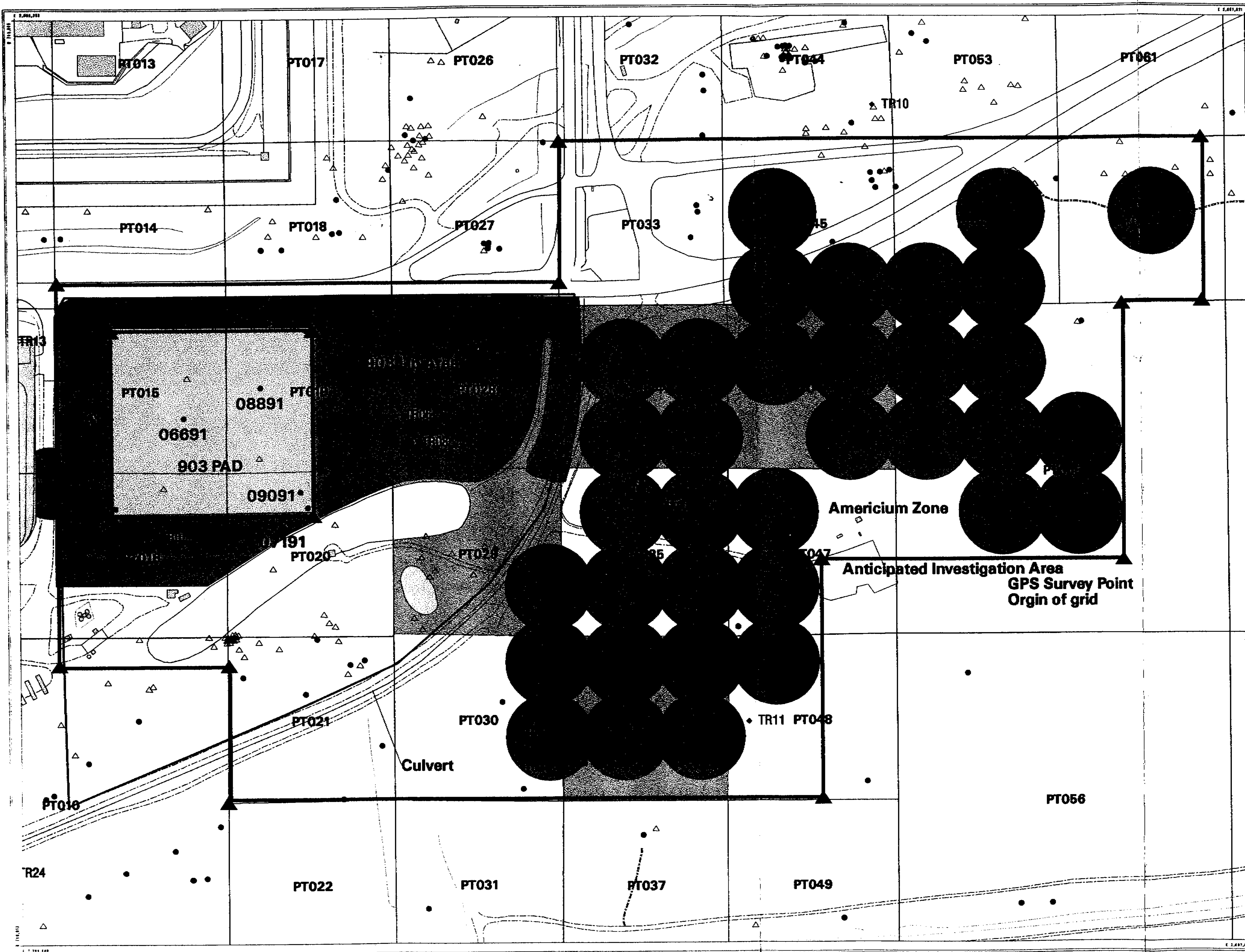
MAP ID: 98-0014

December 15, 1997



Sampling and Analysis Plan for the Site Characterization at the 903 Drum Storage Area, 903 Lip Area and Americium Zone

Investigation Area Location Map

Figure 1.2

Explanation

- HPGe 150 foot FOV Circles (above 10pCi/g Am-241)
- Plots above Tier I Action Levels
- Proposed GPS Survey Point
- Groundwater Well Locations
- Borehole Locations
- Soil profile Sampling Sites
- 1976 Soil Removal Area (approx)
- 1978 Soil Removal Area (approx)
- 1970 Soil Fill Area

Standard Map Features

- Buildings and other structures
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Paved roads
- Dirt roads

DATA SOURCE:
HPGe data from Ron Rahman, Gamma Survey Group, Safeguard Measurements, EG&G Rocky Flats, Inc. June 1994

Scale = 1 : 2160
1 inch represents 180 feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

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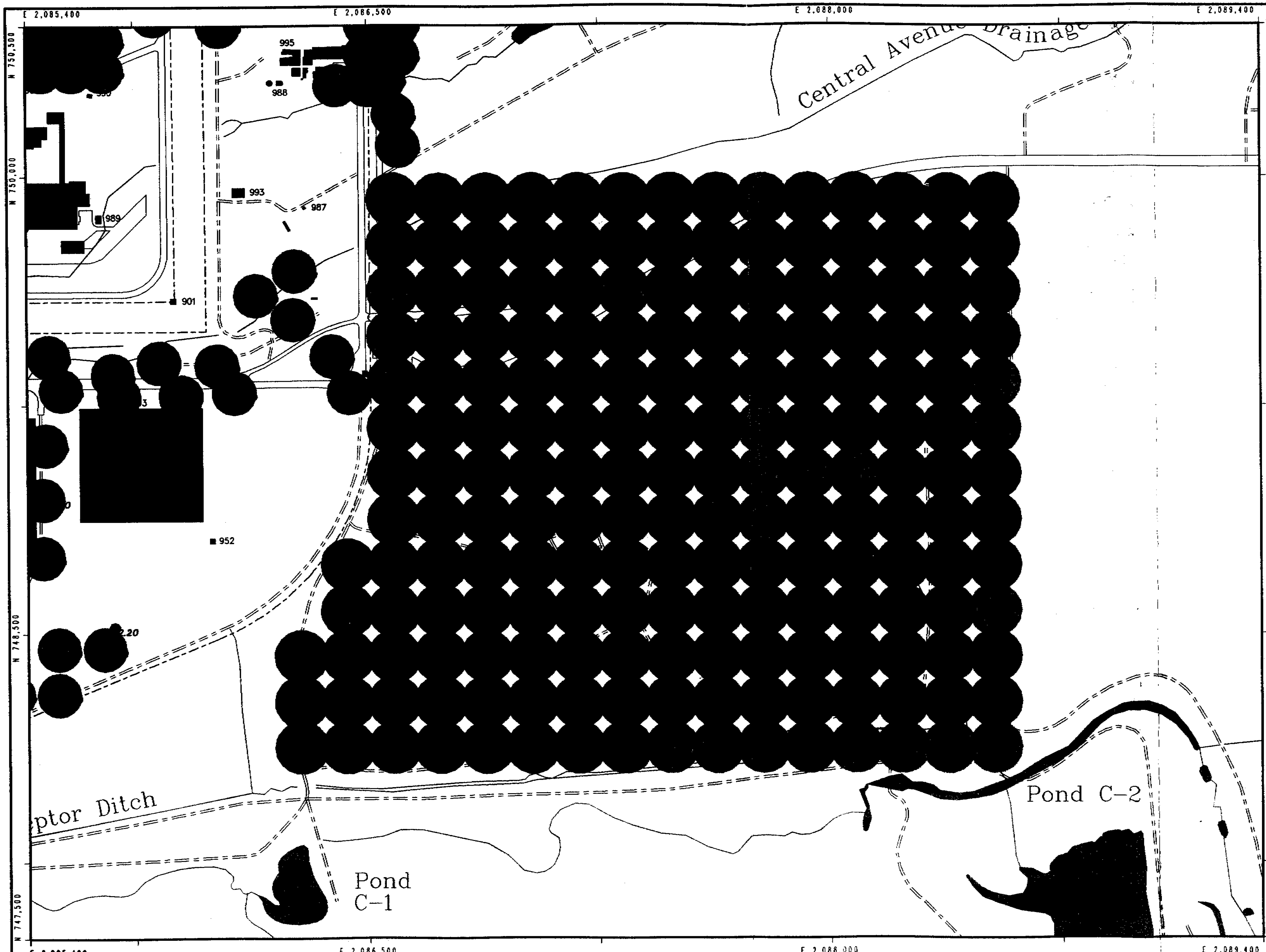

Sampling and Analysis Plan for the Site Characterization at the 903 Drum Storage Area, 903 Lip Area and Americium Zone

1994 HPGe Survey Data for Am-241 in Investigation Area

Figure 1.3

HPGe Data Ranges-- pCi/g for a Field of View of 150 feet (DOE, 1995a)

- 0.0 - 0.1
- 0.1 - 1
- 1 - 10
- 10 - 100
- 100 - 1000
- 1000 - 10000

Standard Map Features--

- Buildings and other structures
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences
- Rocky Flats boundary
- Paved roads
- Dirt roads

NOTE:
Raw field data which has not been evaluated and may be influenced by building shine.

The HPGe field of view (FOV) or radius of influence, assumes a homogeneous surface distribution. The FOV represents a circle where 90% of the flux originates. The radius, for each HPGe sampling location, is based on the height of the detector above the ground.

The FOV for the majority of the points is 150 feet; however, two of the survey locations have a FOV of less than 150 feet.

DATA SOURCE:
HPGe data from [illegible], Gamma Survey Group, Safeguard Measurements, EG&G Rocky Flats, Inc. June 1994
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs. [illegible]

150 0 300ft

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MAP ID: Invest-area December 16, 1997

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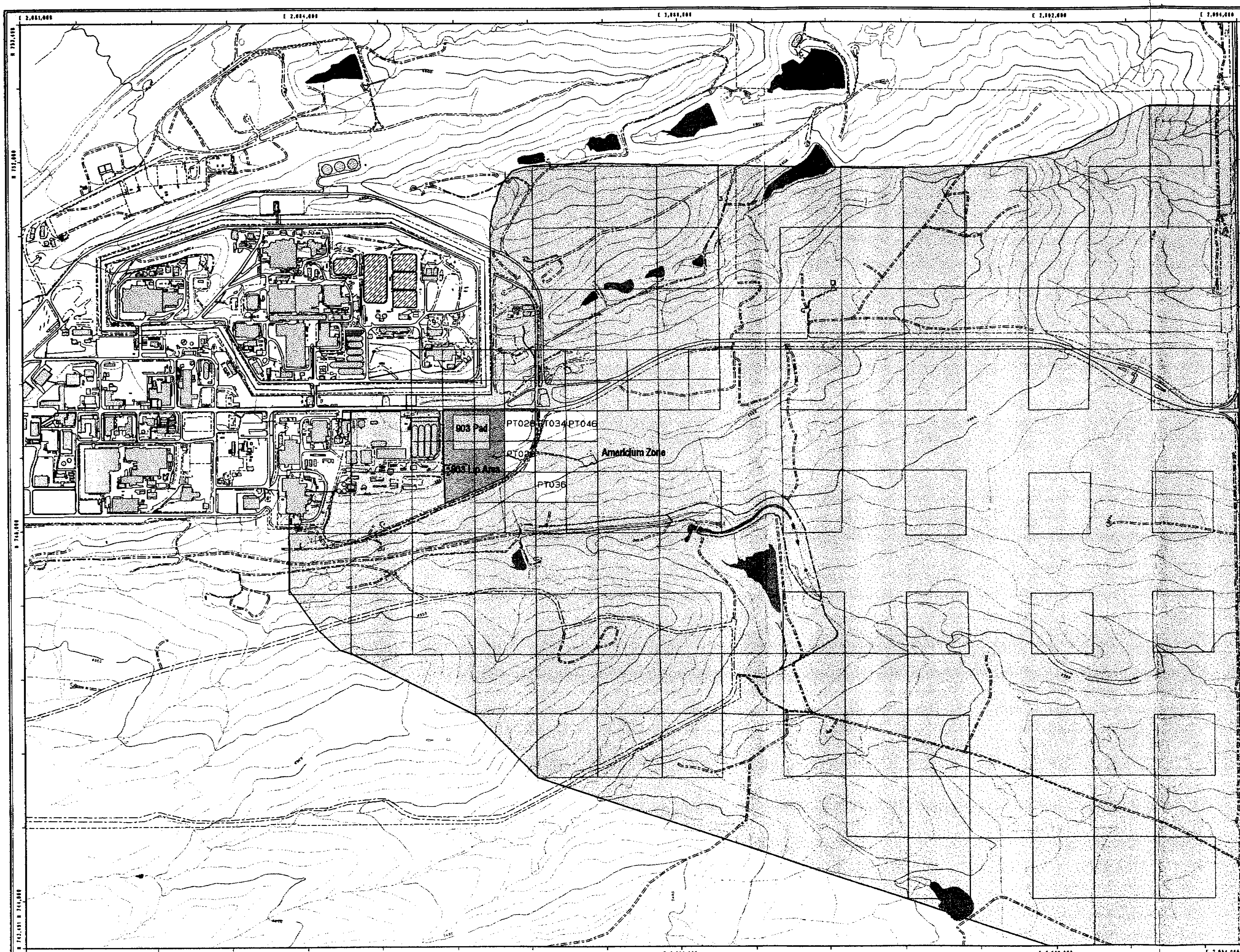

Sampling and Analysis Plan for the Site Characterization at the 903 Drum Storage Area, 903 Lip Area and Americium Zone

OU2 Phase II RFI/RI Surface Soil Sampling Plots Study Area

Figure 1.4

EXPLANATION

- CDH & RF Surface Soil Sampling Plots - (DOE, 1995a)
- Study Area
- 903 Lip Area
- Sampling Plots Exceeding Tier I Soil Actions Levels - Radoinuclides (DOE, 1995a)

Standard Map Features

- Buildings and other structures
- Solar evaporation ponds
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Contour (20-Foot)
- Paved roads
- Dirt roads

N

Scale = 1 : 11890
1 inch represents approximately 991 feet

250 0 500 1000ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

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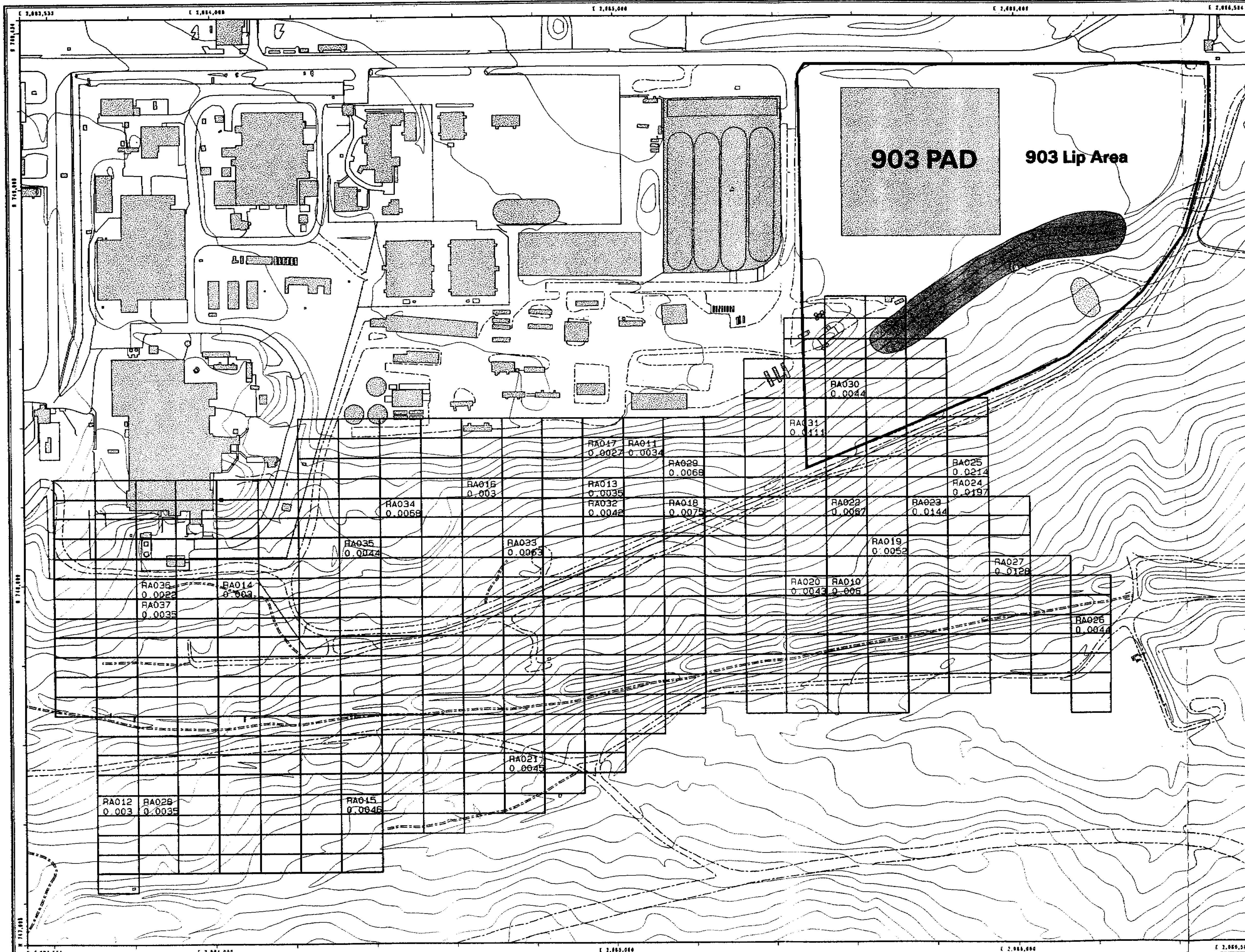
December 15, 1997



Sampling and Analysis Plan for the Site Characterization at the 903 Drum Storage Area, 903 Lip Area and Americium Zone

OU1 Phase III RFI/RI Surface Soil Sampling Locations, Study Area

Figure 1.5

EXPLANATION

5 Foot contours

903 Pad Lip Area

1976 Soil Removal Area (approx)

1978 Soil Removal Area (approx)

RA034 0.0068 — Plot Number, Sum of Ratios - Radionuclides

Standard Map Features

Buildings & other structures

Fences and other barriers

Paved roads

Dirt roads

DATA SOURCE: Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs. 1/95

50 0 100 200 Feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

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MAP ID: 97-0039

December 16, 1997

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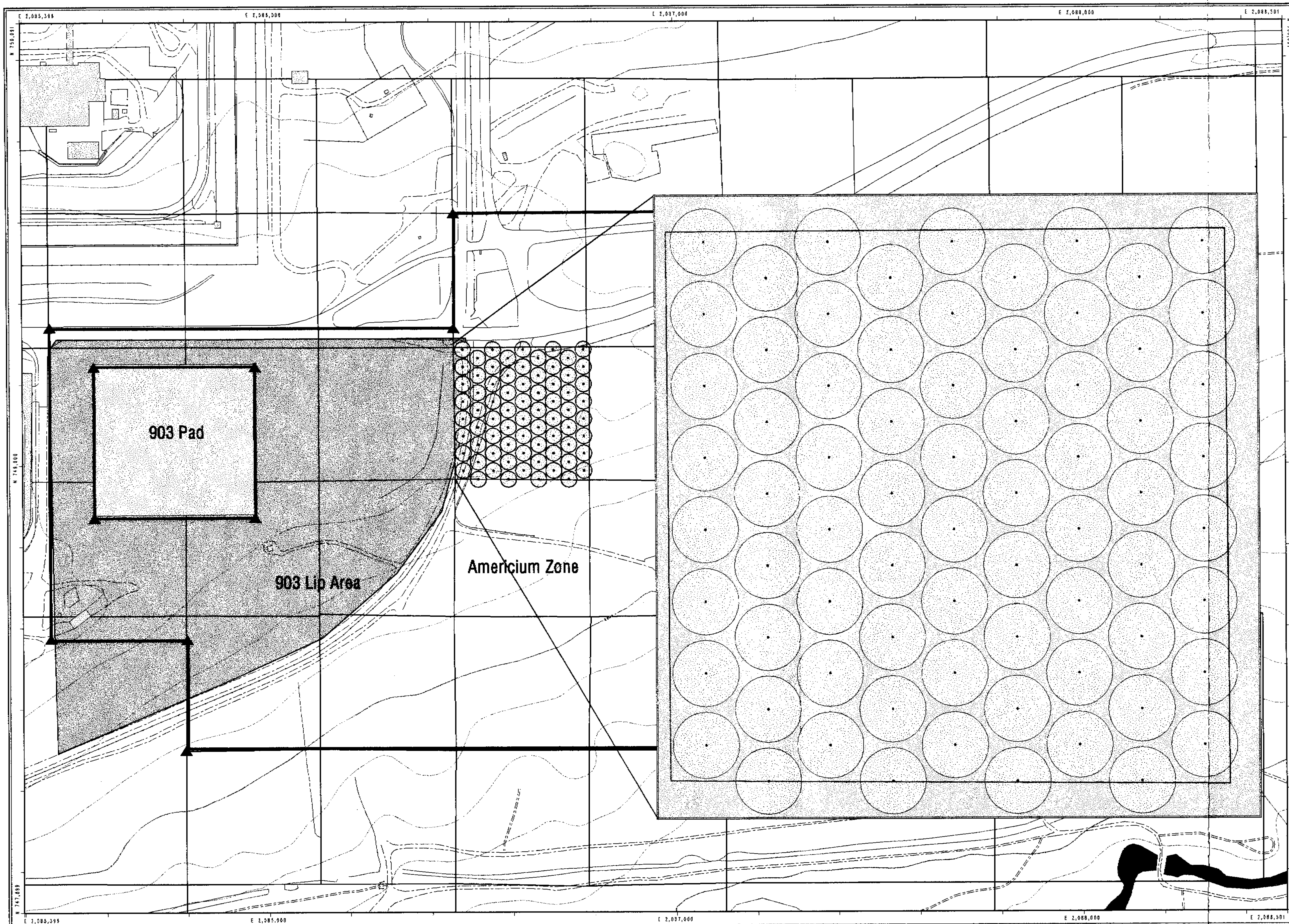

Sampling and Analysis Plan for the Site Characterization at the 903 Drum Storage Area, 903 Lip Area and Americium Zone

Typical HPGe Survey Grid

Figure 3.1

EXPLANATION

Surface Soil Sampling Plot

HPGe Survey Location

HPGe Measurement Field of View

903 Lip Area

Standard Map Features

Buildings and other structures

Lakes and ponds

Streams, ditches, or other drainage features

Fences and other barriers

Contour (20-Foot)

Paved roads

Dirt roads

DATA SOURCE:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas.
Digitized from the orthophotographs. 1/95
Topology (contours) were derived from digital elevation model (DEM) data by Morrison Knudsen (MK) using ESRI Arc TIN and LATTICE to process the DEM data to create 5-foot contours.
The DEM data was capture by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at ~ 10 meter resolution.
The DEM post-processing performed by MK, Winter 1997.

Scale = 1 : 2840
1 inch represents approximately 237 feet

50 0 100 200ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
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MAP ID: 98-0014

August 24, 1998

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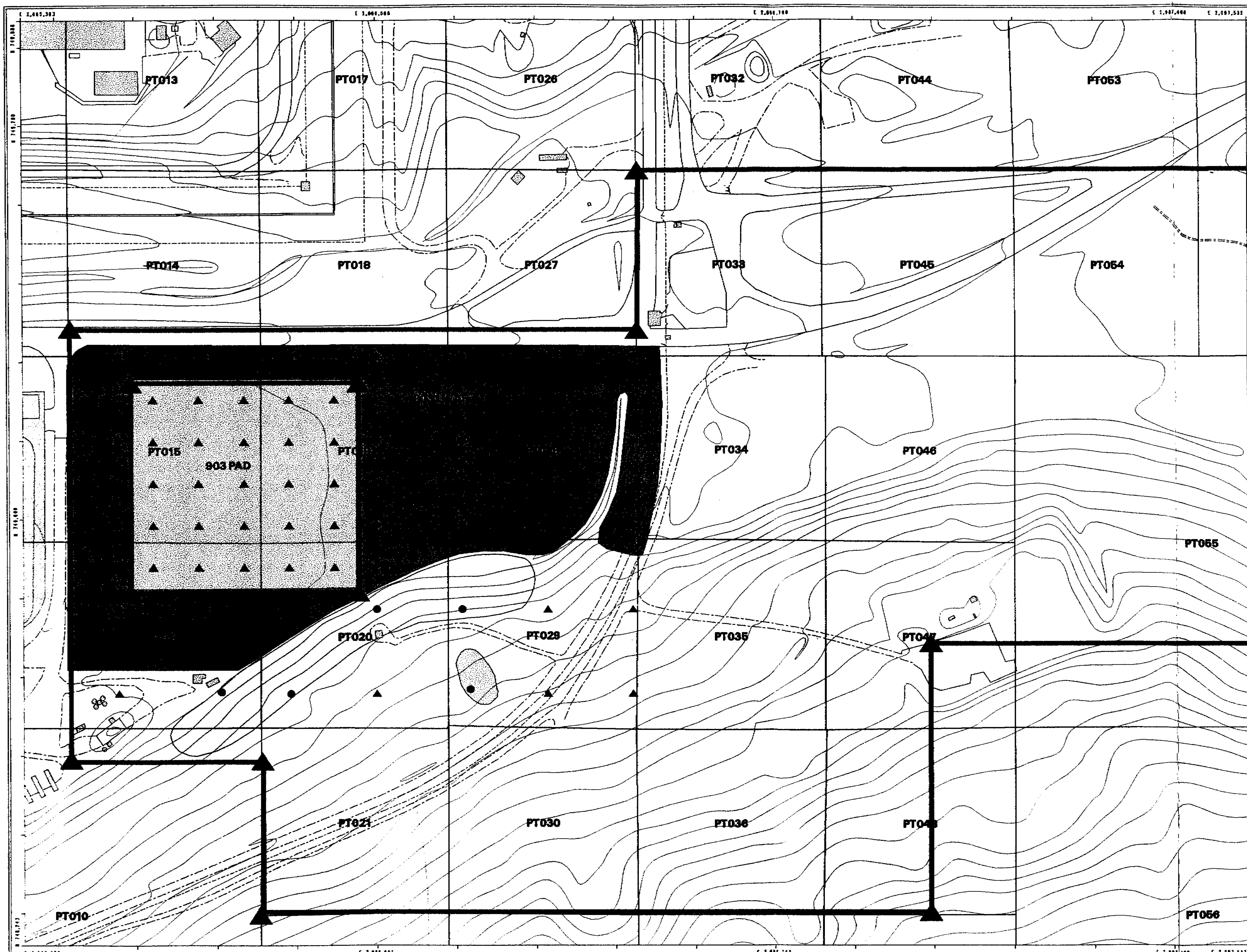

Sampling and Analysis Plan for the Site Characterization at the 903 Drum Storage Area, 903 Lip Area and Americium Zone

Radiological Subsurface Sampling Locations 903 Lip Area

Figure 3.3

EXPLANATION

- 5 ft elevation contour
- Investigation Area
- 1976 Soil Removal Area (approx)
- 1978 Soil Removal Area (approx)
- 1970 Soil Fill Area
- Optional Borehole Locations to close to grid in 903 Pad Lip Area Boreholes
- Soil Borings
- 903 Pad Boreholes

Standard Map Features

- Buildings
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences
- Paved roads
- Dirt roads

50 0 100 200ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

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MAP ID: 97-0149

December 15, 1997

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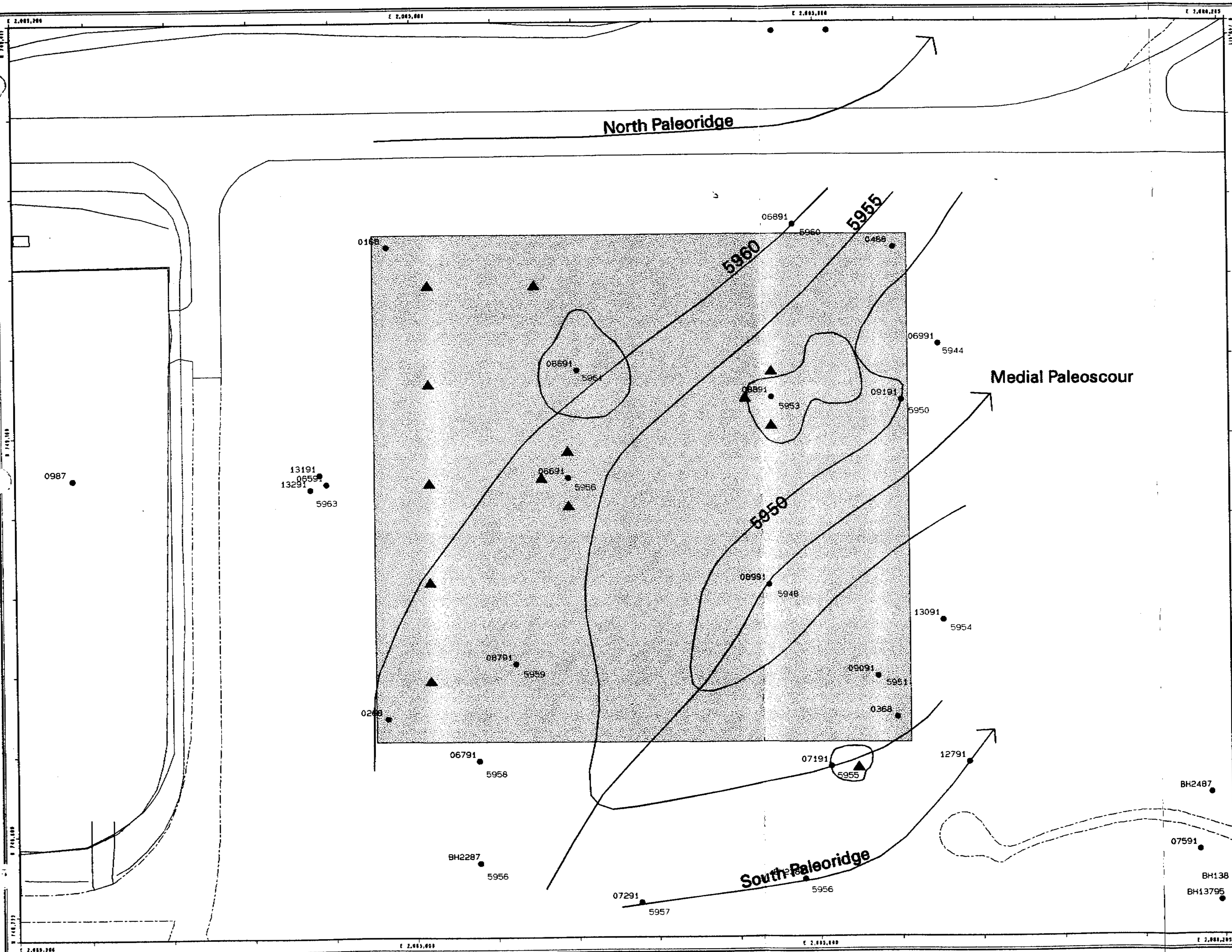

Sampling and Analysis Plan for the Site Characterization at the 903 Drum Storage Area, 903 Lip Area and Americium Zone

VOC Investigation Borehole Location Map

Figure 3.4

EXPLANATION

- ▲ Proposed Boreholes
- ● Groundwater Monitoring Well — Location Code-left, Top of Bedrock Elev.-right
- ● Borehole — Location Code-left, Top of Bedrock Elev.-right
- Top of Bedrock Elevation Contours
- Soil Gas Concentrations > 100 ppm
- Paleotopographic Trends
- Individual Hazardous Substance Site (IHSS 112)

Standard Map Features

- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Paved roads
- Dirt roads

N

Scale = 1 : 840
1 inch represents 70 feet

25 0 50 100ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:

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MAP ID: 97-0149

December 16, 1997

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